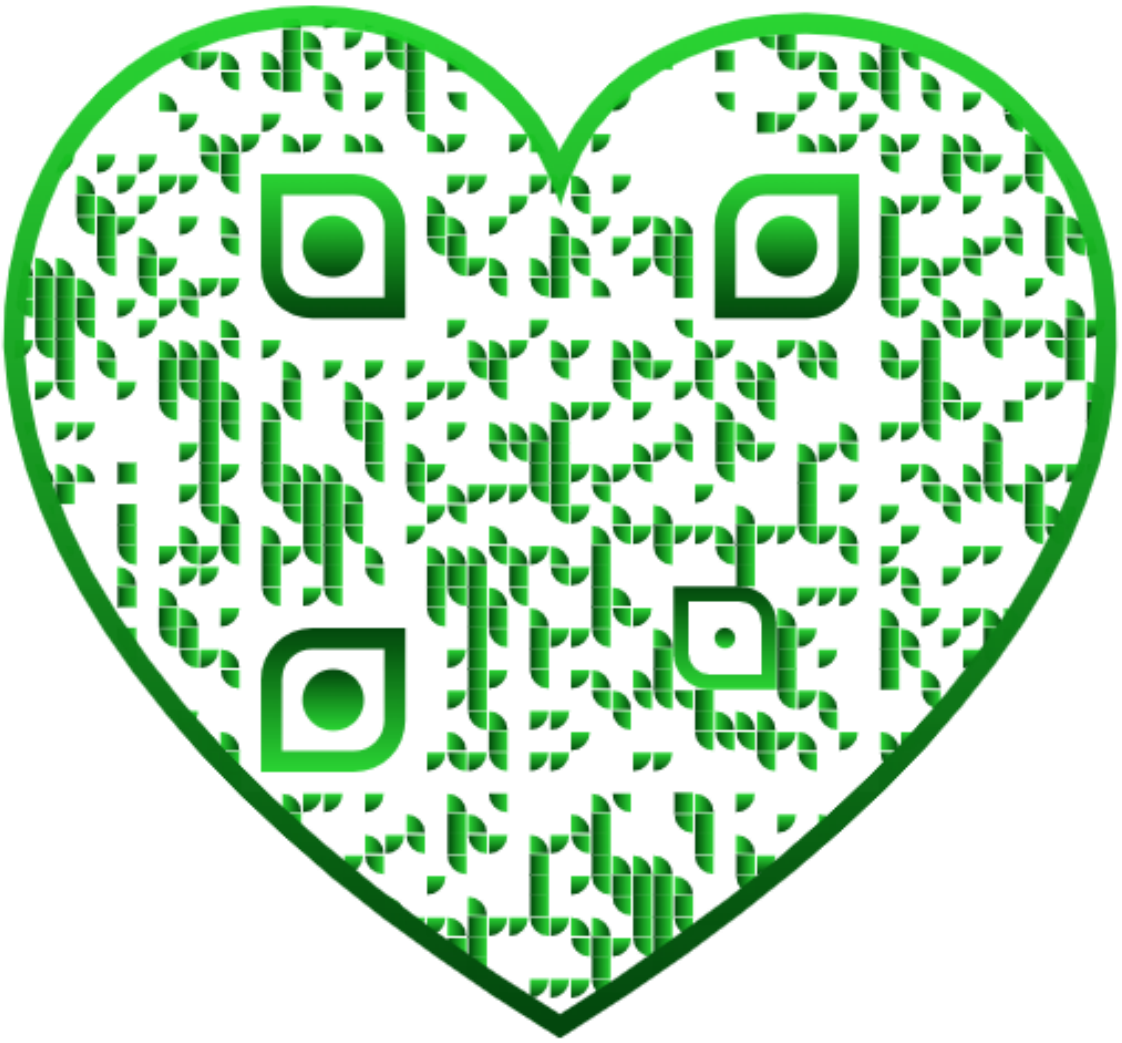
Epidemiology of malnutrition in Yemen 2023

Presented by:

Group 6 (A-B) - Batch 37

Supervised by:

Prof. Ahmed Al-Haddad
Dr. Aisha Al-Da’eri



2023

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Dedication

This scientific paper is dedicated :-
To the soul of the deceased of science and homeland
Dr. Ammat-Allateef Abu Talib,
To the soul of our colleague **Sala Abdullateef Alsharafi**, May Allah mercy them,
To our fathers and mothers, the mountains on which we are based, who are burning themselves for us.
To our brothers and sisters in whom we get stronger with.

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Abbreviations

UDHR	Uiversal Declaration of Human Rights
WHO	World Health Organization
WFF	World Food Program
PEM	Protein energy malnutrition
WAZ	Weight for age z-score
WHZ	weight for height z-score
HAZ	Height for age z-score
GAM	Global acute malnutrition
NCHS	National center for health statistics
BMI	Body mass index
EED	Environmental enteric dysfunction
PEE	Pediatric environmental enetropathy
MUAC	Mid-upper arm circumference
UNICEF	United Nation's Children Fund
RUFTs	Ready-to use therapeutic foods
GMP	growth monitoring and promotion
WASH	water sanitation and hygiene
SSN	social safety net
SAM	severe acute malnutrition
MAM	moderate acute malnutrition
DHS	Demographic health survey
MMS	multiple-micronutrient Supplement
MND	micronutrient deficiencies
NCD	non-communicable diseases

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Chapter 1

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Definitions Of Malnutrition:

Malnutrition is defined as not having enough energy or nutrients to live a physically active and healthy life. It encompasses both over nutrition and undernutrition and has direct negative consequences in terms of disease and disability, brain development, educational attainment and income potential for individuals and communities. Adequate nutrition is therefore a key factor to inclusive and equitable growth and development.

Malnutrition is a universal problem that has many forms. It affects most of the world's population at some point in their lifecycle, from infancy to old age. No country is untouched. It affects all geographies, all age groups, rich people and poor people, and all sexes. It is a truly universal problems

Types of malnutrition

Malnutrition is a group of conditions in children and adults generally related to poor quality or insufficient quantity of nutrient intake, absorption, or utilization.

There are three major types of malnutrition:

- Protein-energy malnutrition - resulting from deficiencies in any or all nutrients
- Micronutrient deficiencies can cause several serious health issues. A lack of iron, folate and vitamins B12 and A can lead to anaemia. Anaemia is a condition in which there is a reduced number of red blood cells or hemoglobin concentration, causing fatigue, weakness, shortage of breath and dizziness.
- Overweight and obesity is when BMI is 24.9 kg/m^2 or above (overweight) and 30 kg/m^2 or above (obesity) which indicates that they are too hefty for their height. This is the outcome of an imbalance between the amount of energy consumed and the amount of energy used.

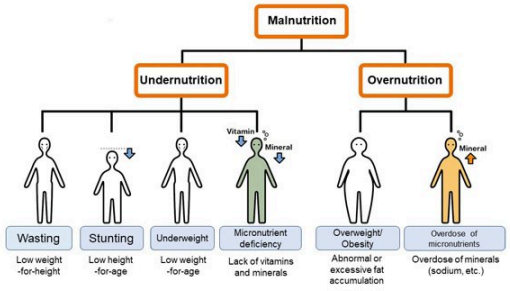

Figure 1: Types of malnutrition, under-nutrition and over-nutrition.

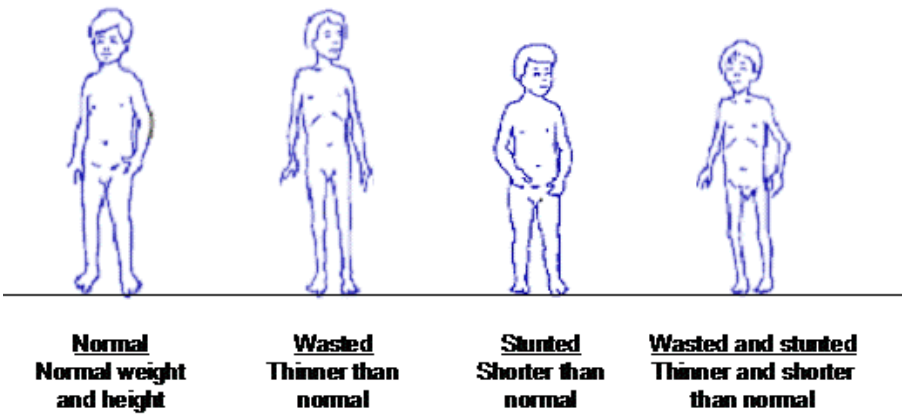

Figure 2 Contrast between being normal, wasted, stunted, and being wasted and stunted simultaneously.

Globally, individuals consume more sugary and calorie-dense foods and beverages while engaging in less physical activity, and diet related non-communicable illnesses.

Type	Appearance	Cause
Acute malnutrition	Wasting or thinness	Acute inadequate nutrition leading to rapid weight loss or failure to gain weight normally
Chronic malnutrition	Stunting or shortness	Inadequate nutrition over long period of time leading to failure of linear growth
Acute and chronic malnutrition	Underweight	A combination measure, therefore, it could occur as a result of wasting, stunting, or both

Table 1: Types of malnutrition, their appearance, and their causes.

- **Protein-energy malnutrition**

There are three types of protein-energy malnutrition in children:
These forms of protein-energy malnutrition in children can be pictured like this:
Wasting and stunting are very different forms of malnutrition. Stunting is chronic and its causative factors are poorly understood. Stunting usually does not pose an immediate threat to life and is relatively common in many populations in less-developed countries. This is not to say that it is unimportant, just less important than wasting in humanitarian emergencies. Wasting results from an acute shortage of food, is reversible with refeeding, and has a relatively high mortality rate. For these reasons, wasting is the highest priority form of malnutrition in humanitarian emergencies.

Historical overview

Humans have always struggled with hunger. However, knowledge of the qualitative characteristics of malnutrition was not well known until the early 20th century.
People from all over the world have known for a long time how important it is to eat particular foods in order to avoid the modern-day symptoms of malnutrition. However, it seems that this knowledge has been continually lost and then found again. For instance, it has been claimed that ancient Egyptians were aware of the signs of scurvy. Much later, in the 14th century, Crusaders occasionally employed anti-scurvy strategies, such as ensuring that citrus fruits were planted on Mediterranean islands so that they could be consumed on sea voyages. However, it seems that Europeans have forgotten the significance of these measures for a number of

centuries.They rediscovered this information in the 18th century, and by the beginning of the 19th century, every crew member on Royal Navy ships was receiving regular doses of lemon juice. The British gained a substantial advantage in the Napoleonic Wars as a result of the drastically decreased number of scurvy deaths among British sailors. The Royal Navy switched from lemons to limes later in the 19th century (not knowing at the time that lemons are much more effective at avoiding scurvy).(Ruxin, 1996; Vernon, 2007)

According to historian Michael Worboys, between World Wars I and II, the science of nutrition was largely created and developed. The development of science built on earlier studies like Casimir Funk's 1912 formulation of the idea of vitamins. In the 1920s and 1930s, there was a rise in the scientific research of malnutrition; this trend continued after World War II.

Malnutrition eradication became a top priority for non-governmental organizations and United Nations organizations. The precise strategies and priorities for doing this tended to change over time, with varying degrees of focus on distinct malnutrition conditions like Kwashiorkor or Marasmus; varying levels of concern on protein deficiency compared to vitamins, minerals, and a lack of raw calories; and varying priorities given to the problem of malnutrition in general compared to other health and development issues. With the advent of the Green Revolution in the 1950s and 1960s, malnutrition prevention skills significantly improved. (Ruxin, 1996; Vernon, 2007; Grigg D, 1981).

The Universal Declaration of Human Rights (UDHR), adopted in 1948, was one of the first formal international documents to address global malnutrition and food security. This document claimed that a sufficient right to a standard of living included access to food (Grigg D, 1981). The International Covenant of Economic, Social, and Cultural Rights, a convention ratified by the United Nations General Assembly on December 16, 1966, affirmed the right to food. People have the right to food, which gives them the freedom from hunger, food insecurity, and malnutrition. (Right to food, 2019) 166 countries have ratified the treaty as of 2018, and by doing so, they committed to using all of their available resources towards achieving the right to adequate food.

The first World Food Conference, which was held in Rome, Italy, in 1974, was the result of increased worldwide concern over having access to enough food after the 1966 International Covenant. All 135 countries present at the 1974 World Food Conference adopted a UN resolution on November 16, 1974, titled "Universal Declaration on the Eradication of Hunger and Malnutrition." (OHCHR, n.d.) This legally non-binding agreement outlined some goals for countries to adhere to in order to adequately address the world food crisis. In the end, this document outlined and offered recommendations for how the world community as a whole could cooperate to combat and resolve the expanding global problem of malnutrition and hunger.

The Additional Protocol to the American Convention on Human Rights in the area of Economic, Social, and Cultural Rights was adopted in 1978 by many countries in the Americas with the stated goal of "to consolidate in this hemisphere, within the framework of democratic institutions, a system of personal liberty and social justice based on respect for the essential rights of man."

The adoption of the right to food was included in this document. (Oas.org, 2020)
The Food and Agriculture Organization's 1996 Rome Declaration on World Food Security was a later milestone in the history of global initiatives to combat hunger. This statement reiterated everyone's right to access healthy food, while also ensuring that everyone has enough to eat. It also established goals for all countries to strengthen their commitment to food security by reducing the number of people who are underweight by 2015.(www.fao.org, n.d.) The Right to Food Guidelines were adopted by the Food and Agriculture Organization in 2004 and provided nations with a framework for expanding the right to food on a national level.

Epidemiology of malnutrition

Nearly half of all deaths in children under 5 are attributable to undernutrition; undernutrition puts children at greater risk of dying from common infections, increases the frequency and severity of such infections, and delays recovery.(2021, UNICEF)

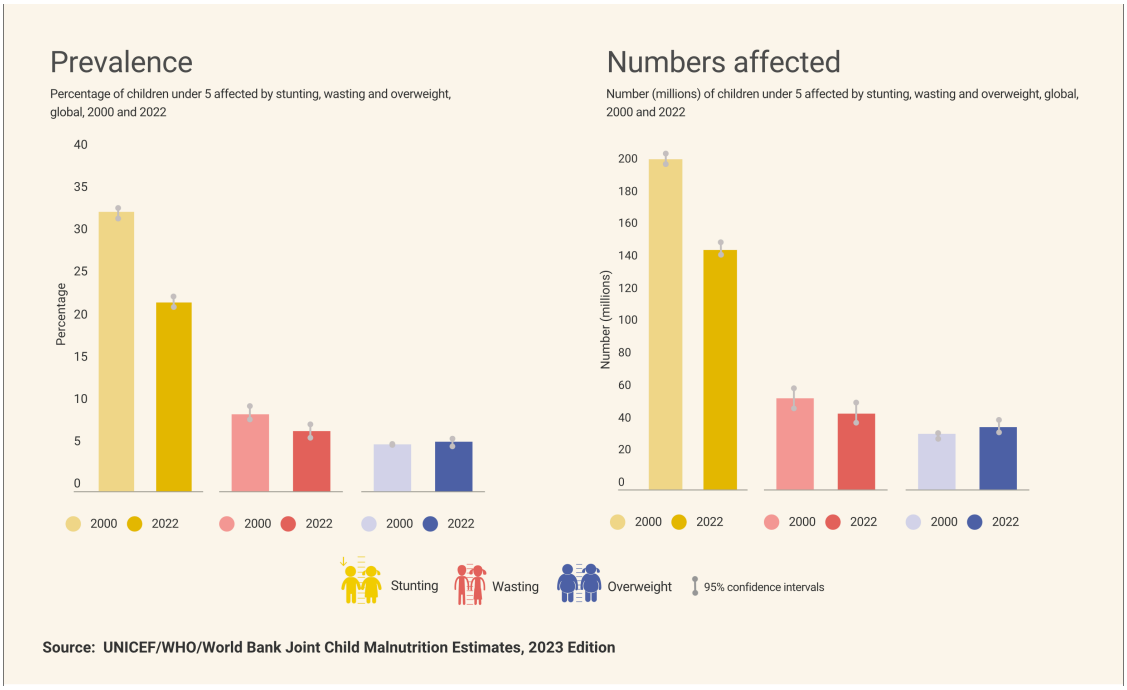

Figure 3: Prevalence of malnutrition among children.

The interaction between undernutrition and infection can create a potentially lethal cycle of worsening illness and deteriorating nutritional status. Poor nutrition in the first 1,000 days of a child's life can also lead to stunted growth, which is associated with impaired cognitive ability and reduced school and work performance. (UNICEF, 2021)
We are still far from a world without malnutrition. While the 2021 edition of the UNICEF-WHO-World Bank Group Joint Malnutrition Estimates shows that stunting prevalence has been declining since the year 2000, more than one in five – 149.2 million children under 5 –were

stunted in 2020*, and 45.4 million suffered from wasting. Meanwhile, the number of children under 5 affected by overweight worldwide has increased from 33.3 million in 2000 to 38.9 million in 2020 .(2021, UNICEF)

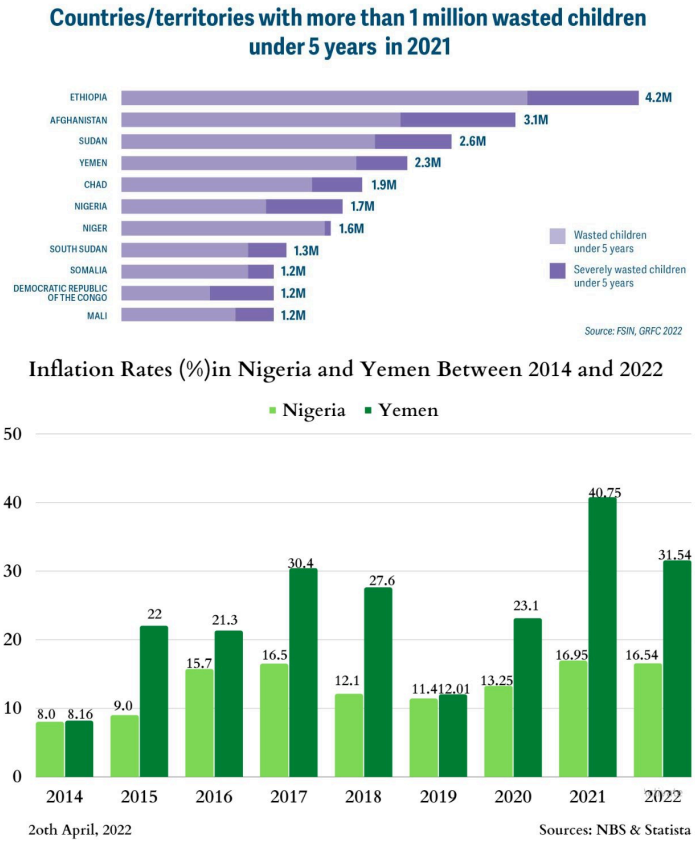

Figure 4: Top: Countries with more than 1 million stunted children under 5 years, Yemen scores 4th. Bottom: Inflation rates of Nigeria and Yemen between 2014 & 2022.

Stunting

In 2020 22*, per cent, or more than one in five children under age 5 worldwide had stunted growth. That said, overall trends are positive. Between 2000 and 2020*, stunting prevalence globally declined from 33.1 per cent to 22 per cent, and the number of children affected fell from 203.6 million to 149.2 million. In 2020*, nearly two out of five children with stunting lived in South Asia while another two out of five lived in sub-Saharan Africa (UNICEF, 2021)

Wasting and severe wasting

In 2020* globally, 45.4 million children under five were wasted of which 13.6 million were severely wasted. This translates into a prevalence of 6.7 per cent and 2.0 per cent, respectively. In 2020*, more than half of all children affected by wasting lived in South Asia and nearly one quarter in sub-Saharan Africa, with similar proportions for children affected by severe wasting. At 14.7 per cent, South Asia's wasting prevalence represents a situation requiring a serious need for intervention with appropriate treatment programs. Under-five wasting and severe wasting are highly sensitive to change. Thus, estimates for these indicators are

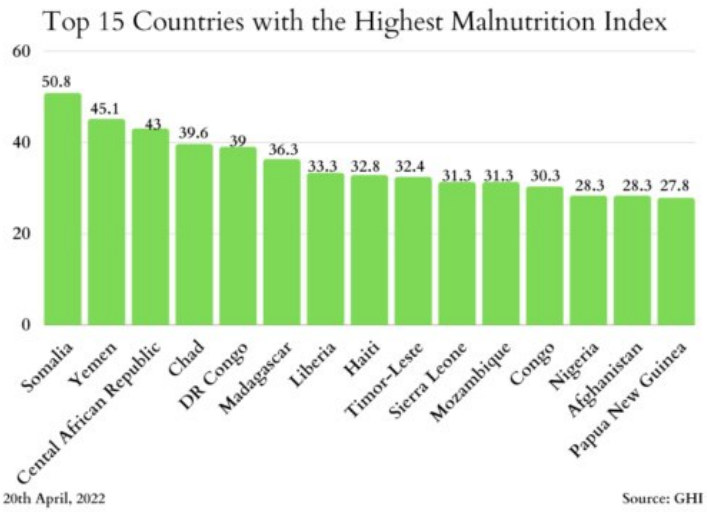

Figure 5: Countries with the highest malnutrition index.

only reported for the latest year (2020) (UNICEF, 2021).

- In 2014, approximately 462 million adults worldwide were underweight, while 1.9 billion were either overweight or obese (WHO, 2021).
- In 2016, an estimated 155 million children under the age of 5 years were suffering from stunting, while 41 million were overweight or obese (WHO, 2021).

Around 45% of deaths among children under 5 years of age are linked to undernutrition. These mostly occur in low- and middle-income countries. At the same time, in these same countries, rates of childhood overweight and obesity are rising (WHO, 2021).

Acute malnutrition is responsible for almost one third of all deaths in children <5 years of age and causes intellectual or cognitive impairment among those who survive (Valeria et al., 2020).
The estimated number of underweight children (weight-for-age Z score < −2) globally is 101 million or 16%. The prevalence of acute and severe malnutrition among children under 5 is above the World Health Assembly target of reducing and maintaining prevalence at under 5% by 2025 (Valeria et al., 2020).

Approximately 2.2 million Yemeni children under the age of five are acutely malnourished, including more than 500,000 who are fighting to survive (Anon, 202 And around 540,000 of them suffering from severe acute malnutrition (www.unicef.org, n.d.). Only 15% of children are eating the minimum acceptable diet for survival, growth and development (www.unicef.org, n.d.).
The high levels of malnutrition are compounded by lack of food, poor feeding practices at home,

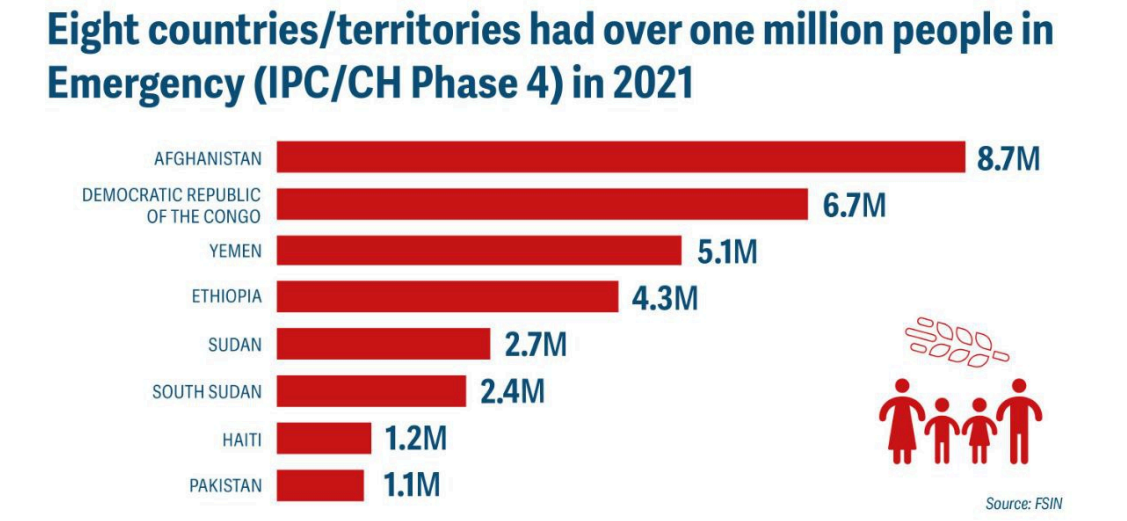

Figure 6: Yemen is one of the countries with more than 1 million in emergency in 2021.

sub-optimal functioning of the health, water and sanitation systems, disease outbreaks and

deteriorating economy. Around 80 per cent of Yemenis are estimated to be in debt and struggling to pay for food, water, transportation and vital health services. With the deepening economic crisis, 1.8 to 2.8 million children are at risk of being pushed into acute food insecurity and many more children could fall into life-threatening severe acute malnutrition (www.unicef.org, n.d.). with one child continuing to die every 10 minutes from preventable causes (UNICEF, 2023).

The nutritional status of women of child bearing age is also a matter of significant concern in Yemen. Since 1997, there has been no improvement in the nutritional status of women and almost a quarter of women are malnourished (www.unicef.org, n.d.). The conflict has also exacerbated the ongoing malnutrition crisis in Yemen (UNICEF, 2023).

Risk Factor Of Malnutrition In Children

The 4 most important elements that make a contribution to malnutrition i n youngsters are:

- Poor maternal fitness
- socioeconomic status
- childhood illness
- Breast feeding
- poor quality of diet
- war

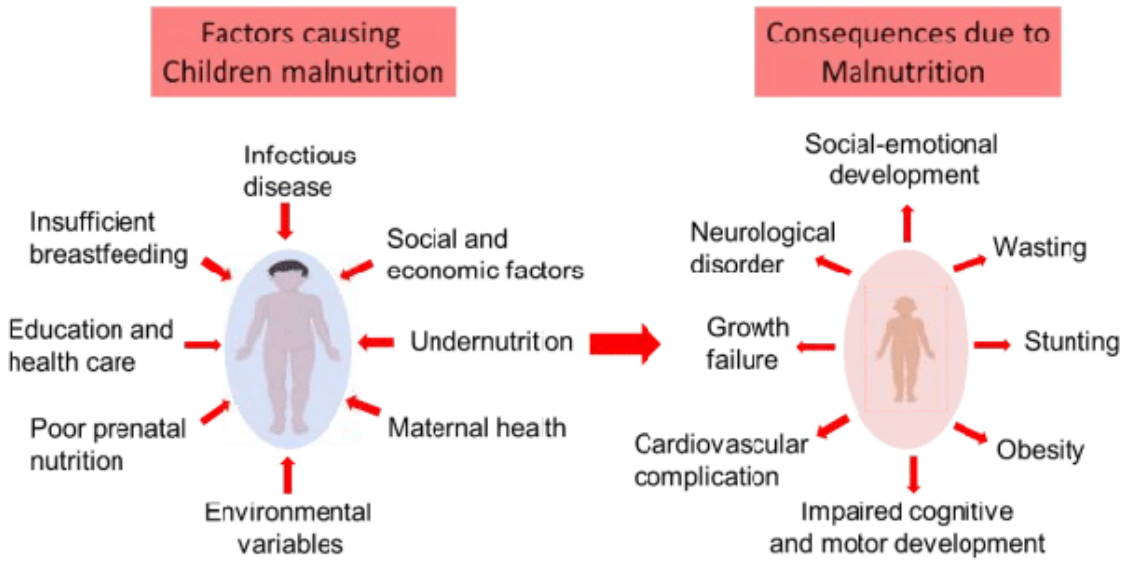

Figure 7: Risk factors and Consequences of malnutrition.

Poor Maternal Health Can Also Cause Malnutrition in Children:

maternal health, also played an important role in child malnutrition. Intake of iron supplements during pregnancy has significant role in child malnutrition.

Significant association of maternal health was found with child malnutrition (Khan, Zaheer and Safdar, 2019). BMI of mother was also a risk factor for child malnutrition

.Mother's age a the time of marriage was also shown to be associated with child malnutrition. (Khan, Khan and Raza, 2015) Mother's knowledge about follow-up after delivery can also enhance the risk of being stunted. Association of child malnutrition was observed with inadequate feeding status. Children who were not exclusively breastfed were found to be at more risk of being stunted and wasted. Attention must be paid towards vaccination of the child. Education of mothers also played a role here. It was observed in a study that usually children do not receive any vaccination except polio. Number of children also affects child malnutrition (Victora et al., 2021).Among women of reproductive age, the prevalence of low body-mass index has been reduced by half in middle-income countries, but trends in short stature prevalence are less evident. Both conditions are associated with poor outcomes for mothers and their children.

Multiple forms of undernutrition among girls and adolescents lead to poor reproductive and other health consequences for women. In addition, they exacerbate the risk of poor birth outcomes, such as fetal losses, fetal growth restriction, and preterm delivery, as well as early life undernutrition and poor cognitive development among offspring. (Tette, Sifah and Nartey, 2015)

The Link Between Socioeconomic Status and Malnutrion in Children:

The major factors for child malnutrition observed by the United Nations Children's Fund (UNICEF) are food insecurity and unhealthy environment, inadequate care and absence of healthcare facilities. There are several other factors that can affect the nutrition status of a child, including poor or low income, illiterate family or parent, knowledge about the use of healthcare facilities (Nisar et al., 2016). The two emerging factors responsible for stunting and wasting are poverty and illiteracy in Pakistan (Khan, Khan and Raza, 2015). Family system also matters in terms of child malnutrition. Child in a joint family system is observed at high risk. Women living in nuclear family find themselves more empowered compared to women living in a joint family. (Khan et al., 2016) Mostly those children suffer from malnutrition who belong to a low-income family. Household and economic conditions are also associated with child malnutrition (Zapata, Soruco and Carmuega, 2019). Socio-economic status and education level are the main social determinants of malnutrition. Social determinants of health are 'the conditions in which people are born, grow, live, work and age, conditions that are mostly responsible for health inequities – the unfair and avoidable differences in health status seen within and between countries.

childhood illness and it's association with malnutrition:

Malnutrition is responsible, directly or indirectly, for 54% of the 10.8 million deaths per year in children under five and contributes to every second death (53%) associated with infectious diseases among children under five years of age in developing countries(Scrimshaw, Nevin Stewart et al., 1968). Examples of how infections can contribute to malnutrition are:

- gastrointestinal infection can lead to diarrhea;
- HIV/AIDS, tuberculosis, and other chronic infections can cause cachexia and anemia;
- intestinal parasites can cause anemia and nutrient deprivation (Strategy for improved nutrition of children and women in developing countries, 1991)

The most common and immediate causes of malnutrition/undernutrition in children are inadequate dietary intake and disease (such as diarrhoea),according to the UNICEF conceptual framework of the causes of malnutrition (Irena, Mwambazi and Mulenga, 2011) and diarrhoea is a major causative factor in malnutrition of children, especially those in low-income countries (Brown, 2003). Diarrhoea illness can lead to malnutrition through reduced nutrient absorption and mucosal damage, as well as through nutrient depletion associated with each episode of diarrhoea (Rodríguez, Cervantes and Ortiz, 2011)

Infection can suppress appetite and directly affect nutrient metabolism, leading to poor nutrient utilization (Vesel et al., 2010)

Breastfeeding

Exclusive breastfeeding is recommended for infants up to 6 months of age because of its benefits in reducing morbidity and mortality.

exclusively breastfed infants had a lower prevalence of stunting, wasting and underweight (Liu et al., 2019). breastfeeding has a positive correlation with cognitive development and early brain functioning compared to formulafeeding (Pravana et al., 2017).

Bivariate analysis showed that mother's age at birth, birth interval, father's educational level, mother's educational level, socioeconomic status, bottle feeding, initiation of breastfeeding, colostrum feeding, exclusive breastfeeding and initiation of complementary feeding were significantly associated with SAM (Munirul Islam et al., 2018).

Duration of exclusive breastfeedingwas significantly greater in non-SAM infants More infants were reported to be still breastfeeding at age 6 months in the non-SAM group compared with the SAM group (10)

diet quality

Poor diet quality is a leading and preventable cause of adverse health globally, which includes both maternal and child health (MCH) and noncommunicable diseases (NCDs). (Gil, Martinez de Victoria and Olza, 2015) a variety of dietary metrics have been developed and used to summarise various components of a diet (eg, adequacy, quality, diversity),

(www.revistanutricion.org, n.d.) dietary practices and consumption patterns, affecting the health of the population (Frojo et al., 2012) most infants were proportionate with hardly any wasting, making the presence of energy deficiency unlikely; therefore, high rates of stunting cannot be explained by energy deficiency. On the other hand, it is now recognised that key micronutrients such as iron and zinc play an important role in infant growth. The early introduction of solid foods after 6 months of age or supplementation with micronutrients becomes critical in terms of optimal growth and development. (Avis, 2019)

impact of war and conflict on malnutrition on children:

Approximately 2 billion people, over a quarter of the world's population, live in countries affected by armed conflict (Loewenberg, 2015) There are around 240 million of children who live in countries that are affected by conflict and fragility.Armed conflict is an important driver of acute malnutrition, a rapid form of weight loss brought on by starvation and/or disease (Brück and d'Errico, 2019; Food Security Information Network. Global Report on Food Crises, 2018) Acute malnutrition among vulnerable and marginalized populations due to armed conflict is a multidimensional problem that deserves a multi-disciplinary response.

An estimated 124 million people are exposed to crisis-level food insecurity, a direct contributor to acute malnutrition, and, at present, all countries at risk of crisis levels of food insecurity experience significant armed conflict (Food Security Information Network. Global Report on Food Crises, 2018; Save The Children, n.d.) For 60 percent of people experiencing acute food insecurity, armed conflict is a key precipitating factor (Corley, 2021). Eight overarching drivers emerged that help to explain how armed conflict drives acute malnutrition in pregnant and breastfeeding women and children. **These drivers included** :

- food as a weapon of war;
- infrastructure destruction;
- destruction of agriculture and persistent insecurity;
- malabsorption malnutrition;
- loss of family providers;
- .foreign economic embargoes;
- the stress of displacement on host communities;
- .maternal stress (Save The Children, n.d.)

Risk Factors Of Malnutrition In General:

Chronic illnesses that commonly are associated with nutritional
Deficiencies, **include the following**:

- Cystic fibrosis
- Chronic renal failure

- Childhood malignancies · Congenital heart disease
- Neuromuscular diseases
- Chronic inflammatory bowel diseases

Pathophysiology

Generally

Inadequate nutritional intake leads to various physiologic adaptations, including growth restriction, loss of fat, muscle, and visceral mass, reduced basal metabolic rate, and reduced total energy expenditure l

1. Immunological change

Loos of delayed hypersensitivity, fewer T lymphocytes, impaired lymphocyte response, impaired phagocytosis secondary to decreased complement and certain cytokines, and decreased secretory immunoglobulin A (IgA) are some changes that may occur. These immune changes predispose children to severe and chronic infections, most commonly, infectious diarrhea,.

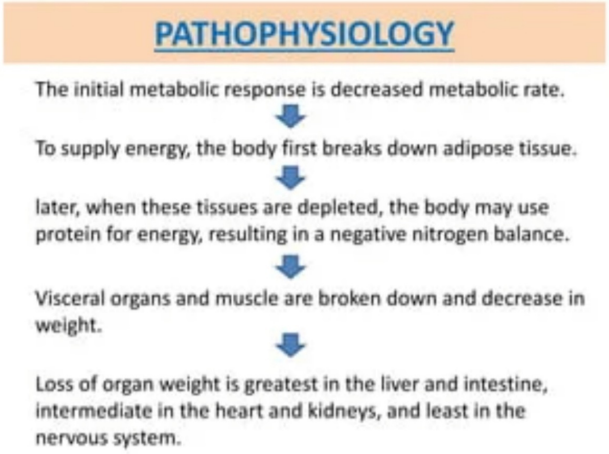
PATHOPHYSIOLOGY
The initial metabolic response is decreased metabolic rate.
To supply energy, the body first breaks down adipose tissue.
later, when these tissues are depleted, the body may use protein for energy, resulting in a negative nitrogen balance.
Visceral organs and muscle are broken down and decrease in weight.
Loss of organ weight is greatest in the liver and intestine, intermediate in the heart and kidneys, and least in the nervous system.

Figure 8: Summary of the pathophysiology of malnutrition

2. The biochemical changes

in acute malnutrition involve metabolic, hormonal, and glucoregulatory mechanisms. The main hormones affected are the ~~*thyroid*~~ hormones, insulin, and the growth hormone (GH). Changes include reduced levels of tri-iodothyroxine (T3), insulin, insulin-like growth factor-1 and raised levels of GH and cortisol. Glucose levels are often initially low, with depletion of glycogen stores. In the early phase there is rapid gluconeogenesis with resultant loss of skeletal muscle caused by use of amino acids, pyruvate and lactate. Later there is the protein conservation phase, with fat mobilization leading to lipolysis and ketogenesis

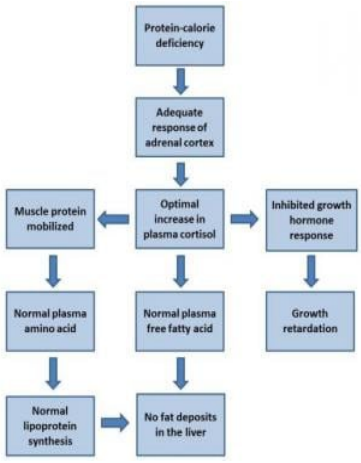

Figure 9: Hormonal adaptations to stress malnutrition.

3. Electrolyte changes

including sodium retention and intracellular potassium depletion can be explained by decreased activity of the glycoside-sensitive energy-dependent sodium pump to increased permeability of cell membranes in kwashiorkor.Organ systems are variably impaired in acute malnutrition. Cellular immunity is affected because of atrophy of the thymus, lymph nodes, and tonsils. There are reduced cluster of differentiation (CD) 4 with normal CD8-T lymphocytes, loss of delayed hypersensitivity, impaired phagocytosis, and reduced secretory immunoglobulin A. Consequently, the susceptibility to invasive infections (urinary, gastrointestinal infections, septicemia, etc.) is increased.
Villous atrophy with resultant loss of disaccharidases, crypt hypoplasia, and altered intestinal permeability results in malabsorption. Other common aspects are bacterial overgrowth and pancreatic atrophy resulting in fat malabsorption; fatty infiltration of the liver is also common. Drug metabolism may be decreased due to decreased plasma albumin and decreased fractions of the glycoprotein responsible for binding drugs.

Deficiency of Nutrients	**Health Problems**
Iron	Irregular body temperature, Improper functioning of the brain
Zinc	Diarrhoea, Hair loss, Stunted growth, Loss of appetite
Iodine	Goitres
Vitamin A	Dry eyes, Night blindness

Table 2: deficiency of various kinds of minerals and micronutrients with the effects their deficiency causes.

4. Cardiac change:

Cardiac myofibrils are thinned with impaired contractility. Cardiac output is reduced proportionate to weight loss. Bradycardia and hypotension are also common in severe cases. The combination of bradycardia, impaired cardiac contractility, and electrolyte imbalances predisposes to arrhythmias. Reduced thoracic muscle mass, decreased metabolic rate, and electrolyte imbalances (hypokalemia and hypophosphatemia) may result in decreased minute ventilation and impaired ventilatory response to hypoxia

5. Neuroral change

Acute malnutrition has been recognized as causing reduction in the numbers of neurons, synapses, dendritic arborizations, and myelinations, all of which resulting in decreased brain size. The cerebral cortex is thinned and brain growth slowed. Delays in global function, motor function, and memory have been associated with malnutrition The effects on the developing brain may be irreversible after the age of 3–4 years.

6. muscular change

malnutrition causes increased muscular fatigue as well as a change in muscle contraction and relaxation patterns. Muscle plasticity works as a compensation strategy for the body in the event of starvation, allowing the metabolic balance to be adjusted. Sustained protein-calorie malnutrition, on the other hand, affects not only the muscle's structural activities but also its metabolic processes, making it difficult to regain nutritional and functional status if not treated adequately.
Even before changes in mass are noticeable, malnutrition impacts muscular function, thus changes in nutritional intake, digestion, or absorption can have a substantial impact on muscle health.

7. respiratory change

As a result, breathing and expectoration become more difficult, increasing the risk of chest infection and respiratory failure. Malnutrition, in particular, can have a negative impact on lung function, resulting in decreased ventilatory drive, lower respiratory muscle performance, modifications to the lung parenchyma, and weakened lung defense mechanisms. If a patient has a severe chronic pulmonary disease or an acute respiratory disease, nutrition supplementation should be considered. Malnourished patients have lower respiratory muscle strength, and nutritional intervention can restore muscular ventilatory performance to normal levels. Furthermore, dietary intake of amino acids and glucose appears to have a significant impact on ventilatory drive.

8. sexual change

Sexual dysfunction can range from a lack of sexual desire, stamina, and libido to more serious sexual problems.

9. Intestinal change

malnutrition is linked to an immature intestinal microbiota characterized by increased prevalence of Enterobacteriaceae. children with moderate acute malnutrition (MAM) have also

Underweight	<18.5
Normal weight	18.5-24.9
Overweight	25-29.9
Obesity class 1	30-34.9
Obesity class 2	35-39.9
Obesity class 3	≥40

Table 3: BMI scores for different bodyweight categories.

Weight for height Z-score	-1 to >-2	-2 to -3	<-3
Weight for age Z-score	-1 to >-2	-2 to -3	<-3
Height for age Z-score	-1 to >-2	-2 to -3	<-3

Table 4: Classification of under-nutrition according to the z-score.

observed heightened systemic inflammation and increased circulating bacterial lipopolysaccharides (LPS; endotoxin). However, the mechanisms that underpin the systemic inflammatory state and endotoxemia, and their pathophysiological consequences, remain uncertain. Understanding these pathophysiological mechanisms is necessary to design targeted treatments that will improve the unacceptable rate of failure or relapse that plague current approaches. Here we use a mouse model of MAM to investigate the mechanisms that promote inflammation in the malnourished host. We found that mice with MAM exhibited increased systemic inflammation at baseline, increased translocation of bacteria and bacterial LPS, and an exaggerated response to inflammatory stimuli. An exaggerated response to bacterial LPS was associated with increased acute weight loss. Remarkably, intestinal inflammation and barrier dysfunction was found in the cecum and colon. The cecum showed a dysbiotic microbiota with expansion of Gammaproteobacteria and some Firmicutes, and contraction of Bacteroidetes. These changes were paralleled by an increase in fecal LPS bioactivity. The inflammatory phenotype and weight loss was modulated by oral administration of non-absorbable antibiotics that altered the proportion of cecal Gammaproteobacteria. We propose that the heightened inflammation of acute malnutrition is the result of changes in the intestinal microbiota, intestinal barrier dysfunction in the cecum and colon, and increased systemic exposure to LPS.

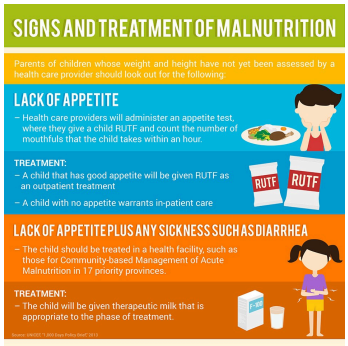
SIGNS AND TREATMENT OF MALNUTRITION
Parents of children whose weight and height have not yet been assessed by a health care provider should look out for the following:
LACK OF APPETITE
– Health care providers will administer an appetite test, where they give a child RUTF and count the number of mouthfuls that the child takes within an hour.
TREATMENT:
– A child that has good appetite will be given RUTF as an outpatient treatment
– A child with no appetite warrants in-patient care
RUTF
RUTF
LACK OF APPETITE PLUS ANY SICKNESS SUCH AS DIARRHEA
– The child should be treated in a health facility, such as those for Community-based Management of Acute Malnutrition in 17 priority provinces.
TREATMENT:
– The child will be given therapeutic milk that is appropriate to the phase of treatment.

Figure 10 Some basic signs of Malnutrition in children along with recommendations of what to do.

Clinical picture: signs & symptoms

Under nutrition

1. Unintended weight loss (low body weight, prominent bones, depleted fat and muscles).
2. Chronic exhaustion (weakness, faintness and fatigue).
3. Dry, pallor and inelastic skin.
4. Delayed wounds repair.
5. Mental illness and behavioral changes (Irritability, Apathy, Depression, Decreased social responsiveness, Anxiety and Attention deficits).
6. Feeling cold most of the time (Low body temperature).
7. Getting ill easily and delayed recovery (Frequent and sever infections).
8. Low heart rate and blood pressureod pressure.
9. Stunted growth and intellectual development in children.
10. Brittle hair, hair loss and hair pigment loss.
11. Swollen stomach; due to ascites.
12. Thin arms and legs with bilateral pitting edema in advanced cases.

Overnutrition

1. Main symptoms of over nutrition are Overweight and obesity.
2. Insulin resistance.
3. Frequent urination.
4. Irritation in eyes.
5. Dry lips.

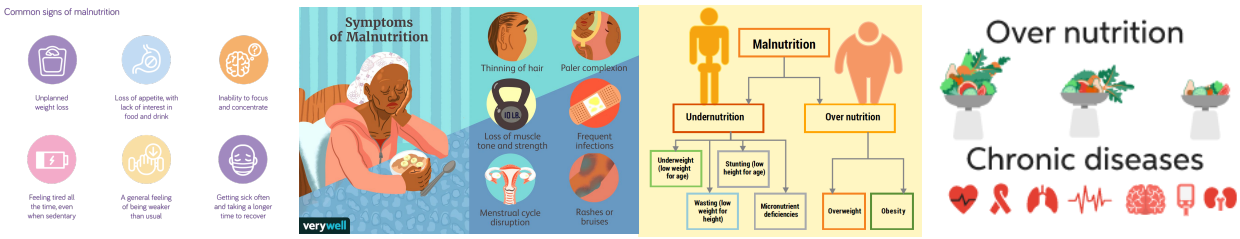

Figure 11: miscellaneous images, the first two of them show some signs and symptoms of malnutrition.

Investigation and diagnosis of malnutrition

The investigation and diagnosis of malnutrition require a comprehensive approach, involving a range of tools and techniques. These include anthropometric measurements, laboratory tests, clinical assessments, and dietary evaluations. (www.who.int, d.n.)

1- **Anthropometric measurements** involve taking physical measurements of the body, such as weight, height, and body mass index (BMI). These measurements can be used to assess whether a patient is underweight, overweight, or obese and can provide an indication of their overall nutritional status.In addition, measurements such as mid-upper arm circumference (MUAC) or skin-fold thickness can be used to assess muscle and fat mass. (Global Nutrition Report, 2020). The measurements which are commonly used to assess malnutrition in children are:

-*Weight-for-Length:* is a measurement that compares child's weight to their length. (Sanitàd, 2006)
-*Weight-for-age (WFA):* is a measurement that compares child's weight to their age. (Sanitàd, 2006)
-*Height-for-age (HFA):* is a measurement that compares a child's height to their age. (Sanitàd, 2006)

The basic indices are used for the previous three measurements are: weight for length Z-score, weight for age Z-score, Height for age Z-score. (Maleta, K, 2006)

-*Mid-upper arm circumference (MUAC):* measures the circumference of the upper arm, which is an indicator of muscle and fat stores. The reference numbers used for MUAC vary depending on the age and sex of the individual being measured.Generally, a MUAC measurement of less than 12.5 cm to 11.5 cm in children aged 6-59 months indicates moderate acute malnutrition. While the measurement of less than 11.5 indicates severe acute malnutrition. (Sanitàd, 2006)

Figure 12: A child's arm is being measured for MAM or SAM. The tape shows it in the junction between SAM and MAM.

2-**Laboratory tests** can also be used to investigate malnutrition. These can include tests for micronutrient deficiencies, such as iron, vitamin A, and zinc, as well as tests for protein-energy malnutrition, such as serum albumin and transferrin. In addition, tests for inflammation and infection can also be used to help identify the underlying cause of malnutrition (Medlineplus.gov, 2019).

3-**Clinical assessments** involve a physical examination by a healthcare professional to identify signs and symptoms of malnutrition. These can include visible signs of wasting or stunting, such as thinning of the limbs or growth retardation, as well as symptoms such as fatigue, weakness, and poor immune function (www.who.int, n.d.).

4-**Dietary evaluations** involve assessing a patient's dietary intake to determine whether they are consuming sufficient amounts of the essential nutrients required for good health. This can involve recording a patient's food intake over a period of time and comparing this to recommended dietary intakes for their age and gender. Nutritional screening and assessment tools such as the Malnutrition Universal Screening Tool (MUST) can also be used to identify patients at risk of malnutrition and to monitor their progress. (www.who.int, d.n.)

Management

Management is based on a series of WHO guidelines and training programs, which are practical and have been widely adopted.and translating these to low-income and middle-income countries, in which severe malnutrition is a daily burden on health systems, remains a challenge (Gross R & Webb P, 2006). In general, management includes the use of therapeutic foods along with antibiotics to treat any underlying infections. Management can be undertaken in communities for children with uncomplicated severe malnutrition (that is, children who are clinically stable and do not display clinical features of complications, especially coincidental infections). The proper management of malnutrition requires careful assessment of the history and the clinical features of the patient. A detailed dietary history is taken.

Place of management

Outpatient treatment

It is not possible to admit all

the children with malnutrition to hospital, as there are never enough beds. Mild cases of kwashiorkor and marasmus are treated effectively in outpatients of health centres and hospitals.Their progress is assessed by gain in weight and improvement of the signs of malnutrition. (At these clinics, the mothers are given health and nutrition education and shown the right kinds of food to give these children at home).

inpatient treatment:

Severe malnutrition cases should be admitted to hospital for more intensive therapy.

Patients who are not improving on outpatient treatment and those with moderate disease who are not likely to do well in the clinics are also admitted to hospital

- clinical assessment & laboratory assessment

Therapeutic foods

Therapeutic foods, such as

A. Ready-to-use therapeutic foods (RUTFs)-

B. F-75 milk-

C. F-100 milk-

were designed for nutritional and metabolic stabilization and rehabilitation, and their use aims to address anticipated calorific needs and treatment stage-appropriate protein,electrolyte and micronutrient requirements. The formulations of F-75 and F-100 were derived and optimized based on metabolic studies of hospitalized children with severe malnutrition, F-75 is used for initial refeeding and F-100 is effective in facilitating rapid catch-up weight gain but might not correct all of the metabolic disturbances in children with severe malnutrition RUTFs were developed to contain the same nutritional content as the F-100 therapeutic milk formula but in a dehydrated form that can be administered in the home environment with no preparation or cooking required and minimal risk of contamination*2.

The predominant formulation of RUTFs consists of peanut paste, milk powder, sugar, oil and micronutrients. The high cost of RUTFs is largely due to their milk powder component, which might be only partially overcome by using local production methods

Trials investigating the use of RUTFs without milk powder have suggested an inferior

effect on child growth (Oakley E, et al, 2010; Bahwere P, et al. 2016)

treated with RUTFs have a higher proportion of recovery and weight gain than children who received a local diet supplemented with additional vitamins and minerals (Manary MJ et al., 2004; Bhandari N, et al., 2016)

The risk of refeeding syndrome might be reduced when children consume therapeutic foods on demand based on their appetite rather than being force-fed using a nasogastric tube (Rytter MJ, et al., 2017; Vemula P, 2015).

Antibiotics

Current guidelines recommend empiric antibiotics for all children with severe malnutrition because of concerns that although some children might not initially present with signs of infection, they might deteriorate suddenly without fever or other warning signs (Chisti MJ et al., 2009; Jones, 2013)

In one study in Malawi, children with severe malnutrition receiving amoxicillin or cefdinir had 36% and 44% reductions in mortality, respectively, and they had faster recoveries than children who received placebo (Trehan I, et al., 2013)

In another study in Niger, mortality

was unchanged in children with uncomplicated severe wasting who had not been previously treated for malnutrition and who were given oral amoxicillin compared with placebo in an

outpatient feeding programme attached to a referral hospital (Isanaka S, et al., 2016) However, amoxicillin treatment was associated with a faster recovery and a 14% reduction in the proportion of children who were referred to hospital in another study (Isanaka S, et al., 2016)
Collectively, evidence from these trials supports the use of empiric antibiotics in outpatient management. (Williams, 2016; Million M, 2017)

Other interventions

Profuse watery diarrhoea, hypovolaemia and shock are common in children with severe malnutrition and are associated with high mortality, despite current management guidelines (Irena AH, 2011; Waterlow J, 1999)
The optimal composition and rate of administration of intravenous or oral fluid therapy, or other supportive therapies, in settings that do not have access to advanced paediatric intensive care is unclear and controversial (Brewster DR, 2011)

Uncomplicated severe malnutrition

can be safely treated in the community via a proactive, public health-based approach to care.
This is made possible by community screening that uses MUAC assessments and by feeding children a RUTF at a dose of 175 kcal/kg per day. (Myatt M, 2006; Trehan I, 2015)
The effectiveness of RUTFs in decreasing the mortality of children with severe malnutrition uncomplicated severe malnutrition (generally >90% of all children with severe malnutrition) to be treated in the community (Trehan I, 2015)

Outcomes of children with uncomplicated severe malnutrition treated in their community are markedly better than of children with complicated malnutrition of similar anthropometric status (Bahwere P, 2012; Shewade HD, et al., 2013)

Complicated severe malnutrition

Children with complicated severe malnutrition (that is, children with a more-severe disease who are sick) are managed as inpatients so that life-threatening complications (such as infections) can be addressed along with nutritional and metabolic deficits.
Therapeutic feeding is cautiously started with milk-based food (specifically, 130 ml/kg per day of F-75, which provides 97.5 kcal/kg per day) that initially contain low levels of protein and sodium and high levels of potassium, which is designed to match the childs reduced When appetite is restored and the signs of infectious complications improve, children transition to RUTFs or milk-based foods with higher energy and protein levels (such as F-100 at 130200 ml/kg per day which provides 130200 kcal/kg per day) to gain weight. No other food should be given, with the exception of breast milk.

Infants <6 months of age with severe malnutrition are fed with breast milk and infant formula, or diluted F-100 milk, often by using a technique called (supplementary suckling)
A key aim of treatment is to establish or reestablish effective exclusive breastfeeding wherever possible. These infants also receive empiric antibiotics. (Network (ENN), 2010)

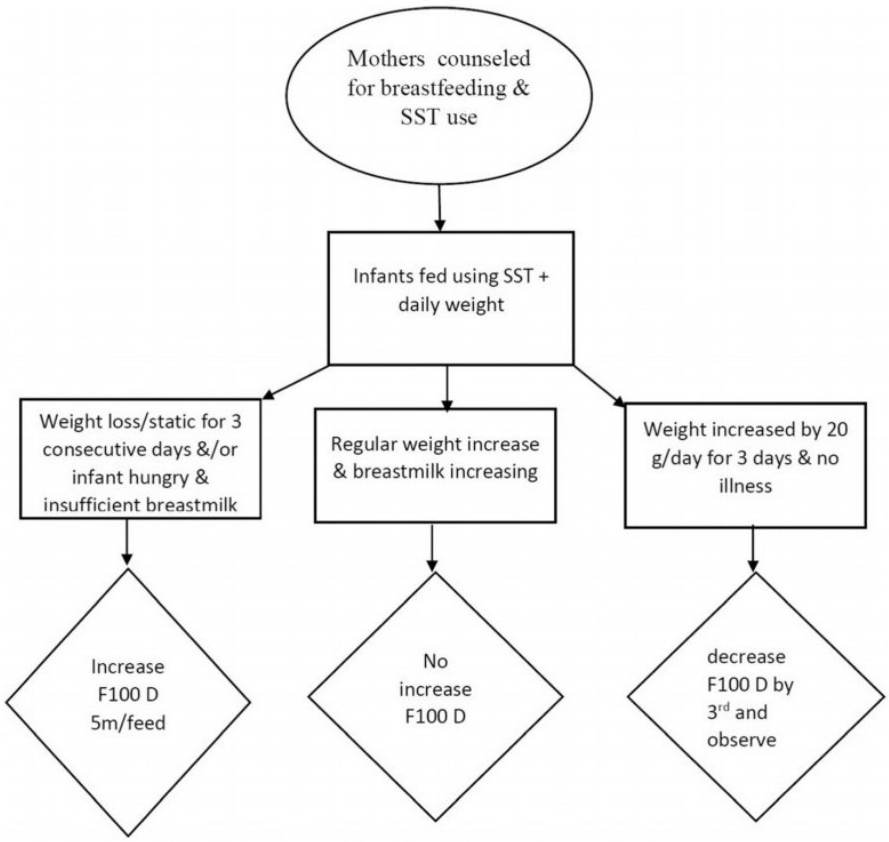
Mothers counseled for breastfeeding & SST use
Infants fed using SST + daily weight
Weight loss/static for 3 consecutive days &/or infant hungry & insufficient breastmilk
Regular weight increase & breastmilk increasing
Weight increased by 20 g/day for 3 days & no illness
Increase F100 D 5m/feed
No increase F100 D
decrease F100 D by 3rd and observe

Fig. 1 Protocol outline of supplementary suckling technique used for infants with SAM in the study

Figure 13: protocol for feeding children with SAM.

Prognosis

Malnutrition is treatable, but some effects can linger. Effects of severe undernutrition, such as blindness from vitamin A deficiency, soft bones from vitamin D deficiency and stunted growth from protein-energy undernutrition in children may not be reversible, even after rehabilitation. Secondary effects of long-term overnutrition, such as insulin resistance and carotid artery disease, may last even after weight loss Up to 10% of a person's body weight can be lost without side effects, but if more than 40% is lost, the situation is almost always fatal. Death usually results from heart failure, electrolyte imbalance, or low body temperature. Patients with semi-consciousness, persistent diarrhea, jaundice, or low blood sodium levels have a poorer prognosis. Since the long-term effects of malnutrition can increase your risk of certain diseases, preventing and treating malnutrition may help reduce the prevalence of chronic health conditions. However, with earlier intervention and good follow-up support, people can make full recoveries. Prognosis for all patients with malnutrition seems to be dependent on the age of the

patient, and the length and severity of the malnutrition, with young children and the elderly having the highest rate of long-term complications and death

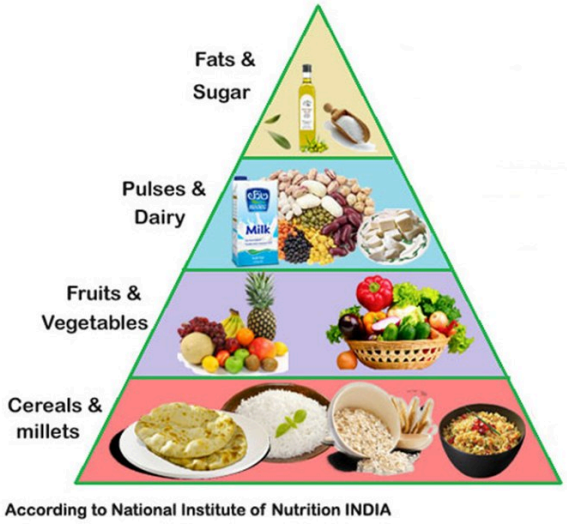

Figure 14: Nutrition pyramid.

Prevention

Malnutrition is a global problem. In both the developed world and the developing world, poverty and a lack of understanding of nutrition are the leading causes. We can help control the disease of malnutrition with better worldwide education and support for the disadvantaged, including access to clean water, nutritious whole foods and medicine. Children and elders who may not be able to advocate for themselves are especially at risk and may need closer attention paid to their diet and health condition.

The best way to prevent malnutrition is to eat a healthy, balanced diet. Try not to miss or skip meals and aim to eat three small meals a day and two to three snacks a day if your appetite is poor. Take drinks after your meal, not before or during as that can fill you up.

A healthy, balanced diet is vital for maintaining health and fitness. To stay healthy, you need to eat a variety of foods from the four main food groups including:

fruit and vegetables

starchy foods, such as rice, pasta, bread and potatoes

milk and dairy foods meat, fish, eggs and beans and other non-dairy sources of protein

If you have enough of all the nutrients your body needs, you will be less likely to overeat trying to satisfy those needs. Some micronutrient deficiencies are common even with a fairly standard diet. A blood test is one way to find out if you could benefit from micronutrient supplements. Your healthcare provider can help you determine the correct dose to take

Chapter 2

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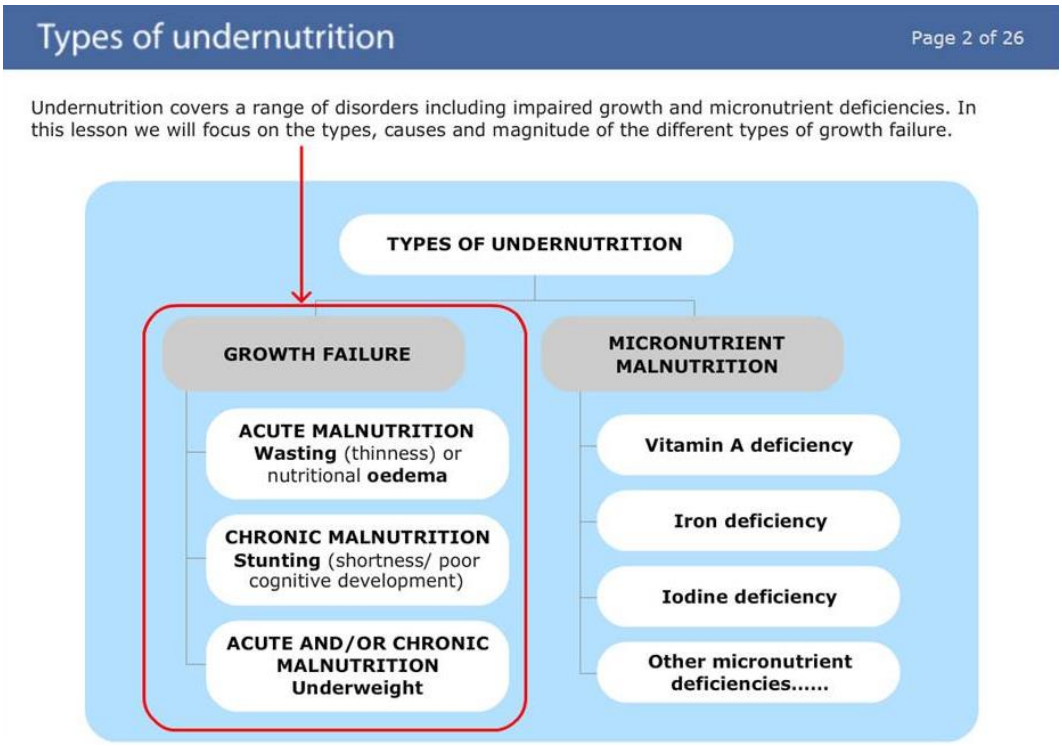
Undernutrition

Definitions

- Undernutrition is a form of malnutrition. (Malnutrition also includes overnutrition.) Undernutrition can result from inadequate ingestion of nutrients, malabsorption, impaired metabolism, loss of nutrients due to diarrhea, or increased nutritional requirements (as occurs in cancer or infection). Undernutrition progresses in stages; it may develop slowly when it is due to anorexia or very rapidly, as sometimes occurs when it is due to rapidly progressive cancer-related cachexia. First, nutrient levels in blood and tissues change, followed by intracellular changes in biochemical functions and structure. Ultimately, symptoms and signs appear. Diagnosis is by history, physical examination, body composition analysis, and sometimes laboratory tests (eg, albumin) (Zubatsky et al., 2021).
- Undernutrition encompasses macronutrient (fats, protein, and carbohydrate) and micronutrient (minerals and vitamins) deficiencies (Black et al., 2008).
- Undernutrition is one of the most common and devastating conditions in the older population and has been defined amongst others as ‘different deviations from the normal nutritional state (Raats, M, 2008).
- Undernutrition is a physical condition characterized by a nutritional disorder resulting from insufficient food intake (undernourishment) and/or poor absorption and/or poor biological use of nutrients consumed as a result of repeated infectious disease. It encompasses being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (wasted) and deficient (status and function) in vitamins and minerals (micronutrient malnutrition). Although the terms malnutrition and undernutrition are often used interchangeably, the first is more extensive in scope (Anderson, J.R. et al., 2019)
- Undernutrition is defined as insufficient intake of energy and nutrients to meet an individual's needs to maintain good health (Waterlow, J.C., 1972).

Types of undernutrition

The three indices (growth failure) " weight-for-age, (height/length) for-age, weight-for-(height/length) are used to identify three nutrition conditions: underweight,
stunting and wasting, respectively. Each of the three nutrition indicators is expressed in standard deviation units (Z-scores) from the median of the reference population based on which undernutrition may be further classified as moderate or severe (Department India, 2013).


Types of undernutrition
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Undernutrition covers a range of disorders including impaired growth and micronutrient deficiencies. In this lesson we will focus on the types, causes and magnitude of the different types of growth failure.
TYPES OF UNDERNUTRITION
GROWTH FAILURE
MICRONUTRIENT MALNUTRITION
ACUTE MALNUTRITION
Wasting (thinness) or nutritional oedema
CHRONIC MALNUTRITION
Stunting (shortness/ poor cognitive development)
ACUTE AND/OR CHRONIC MALNUTRITION
Underweight
Vitamin A deficiency
Iron deficiency
Iodine deficiency
Other micronutrient deficiencies.....

Figure 15: Types of undernutrition

- Stunting:

  A form of growth failure which develops over a long period of time in children under five years of age when growing with limited access to food, health and care The definition of stunting according to the World Health Organization (WHO) is for the "height-for-age" value to be less than two standard deviations of the median of WHO Child Growth Standards (WHO, 2012)

  Stunting is a cumulative process that can begin in utero and continue until the age of 3 years after birth, compromising the growth of a child. The consequences of becoming and remaining stunted are increased risk of morbidity and mortality.

- Wasting:

  Children under five years who are thin for their height because of acute food shortages or disease. Also known as ‘acute malnutrition’, wasting is characterized by a rapid deterioration in nutritional status over a short period of time in children under five years of age. Wasted children are at higher risk of dying. In children, it can be measured using the weight-for-height nutritional index or mid-upper arm circumference (MUAC).

- Moderate and severe thinness or underweight:

  Underweight, based on weight-for-age, is a composite measure of stunting and wasting and is recommended as the indicator to assess changes in the magnitude of malnutrition over time. This condition can result from either chronic or acute malnutrition, or both. Underweight is often used as a basic indicator of the status of a

population's health as weight is easy to measure. Evidence has shown that the mortality risk of children who are even mildly underweight is increased, and severely underweight children are at even greater risk. An underweight child has a weight-for-age Z score that is at least two standard deviations (-2SD) below the median in the World Health Organization (WHO) Child Growth Standard (globalnutritionreport.org, n.d.)

- Micronutrient deficiency:

  Suboptimal nutritional status caused by a lack of intake, absorption or use of one or more vitamins or minerals. Excessive intake of some micronutrients may also result in adverse effects. The international community has focused on several micronutrients that remain issues globally including iron, zinc, vitamin A, folate, vitamin B12 and iodine, as they are the most difficult to satisfy without diverse diets. One general indicator of micronutrient deficiencies is anemia, as this syndrome is caused by the deficiency of many of them, and its effects are exacerbated by several diseases (globalnutritionreport.org, n.d.).

Historical overview of undernutrition

Child nutrition indicators in Yemen are some of the worst among low- to middle-income countries. The reported national prevalence of stunting in Yemen was the second highest in the world following Afghanistan in 2010 (UNICEF, 2014). Both the YNHDS 2013 and WFP 2012 reports showed that the prevalence of underweight, stunting, and wasting was 39.0%, 46.5%, and 16.3%, respectively, among children under 5 years of age in 2013. The NSPMS data present a lower prevalence of child underweight, stunting, and wasting that was 32.4%, 42.5%, 9.7%, respectively for children under 5 years of age probably because of three main reasons.

Type source	underweight	stunting	wasting
YNHDS and WFP	**39.0%**	**46.5%**	**16.3%**
NSPMS	**32.4%**	**42.5%**	**9.7%**

Table 5: Prevalence of different types of malnutrition in Yemen according to YNHDS, WFP and NSPMS in 2013

First, information on child height and/or weight was missing for around 6% of the children; most of these children had a mother with no education (53%) or only basic education (31%), so they may be over-represented among stunted children. Second, our cross-sectional and longitudinal data cleaning excluded 10% more children aged 6–59 months old; most of them also had a mother with low education. Finally, as mentioned before, due to security reasons, the Saa'da and Al-Jawf governorates are not included in this analysis which also made our prevalence to diverge.

Therefore, NSPMS estimate may at least be considered as a lower bound of the prevalence of child stunting in Yemen. This is particularly endorsed by the fact that NSPMS 95% confidence interval actually includes the YNHDS and WFP estimates for child stunting in Yemen (once it varies from 37.9 to 47.3%).

Child malnutrition in Yemen has decreased over the decade before last. Between 1997 and 2003 the percentage of stunted children remained over 50%, but in 2013 it had fallen to 46.5%. Nevertheless, this is not significate change and the Yemeni children are still in a critical situation, especially if we compare the country's statistics with those of a well-nourished population (MOPHP, 2015). In a healthy population, only 2.3% of children would be classified as having low height and/or weight, even if they were 'healthy' individuals with no growth impairment (WHO 1995). In 2015, it was projected that 1 million children under 5 years of age would experience moderate acute undernutrition and that 320,000 would be at risk of severe acute undernutrition (UN, 2015; UNICEF, 2016).

With the increasing political crisis in Yemen, since late 2014 food insecurity has increased because of the sporadic availability of essential food commodities, insufficient fuel, lack of income or employment opportunities, and the disruption of markets and trade. Conflict-related damage to infrastructure, shortages, and a lack of staff are among the causes of the collapse of basic health services in Yemen (UNICEF, 2016). In addition, agricultural production is failing because of inadequate rainfall and the high cost and uneven availability of agricultural inputs (such as seed, fertilizer, farm tools, animal feed, and fuel for irrigation pumps) (UN, 2016). Despite these critical situations and uncertainties, clues to relieve undernutrition should be sought.

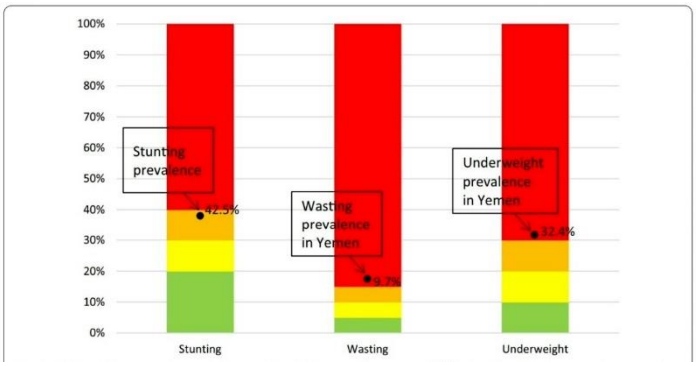


Figure 16: Malnutrition prevalence in Yemen (in 2013)

Epidemiology of undernutrition

Undernutrition remains a major public health concern globally, particularly in low- and middle-income countries approximately 149 million children under the age of five are stunted, 50 million are wasted. also states that undernutrition contributes to 45% of all child deaths and is a leading risk factor for disease burden in low- and middle-income countries (Global Nutrition Report, 2020).

In 2016 alone, childhood undernutrition, i.e., stunting, wasting, and underweight, caused one million deaths globally (Ssentongo P. et al., 2019). Child undernutrition shows significant variations across and within national boundaries. in 2017, the share of undernourished under-five children was 20.4% in Africa, 11.4% in some regions of Asia, and 6.1% in Latin America (WHO, 2018). in 2020, almost 149 million under-five children were stunted, 59 million were wasted, and 85 million were moderately or severely underweight (GHO, WHO, 2021).

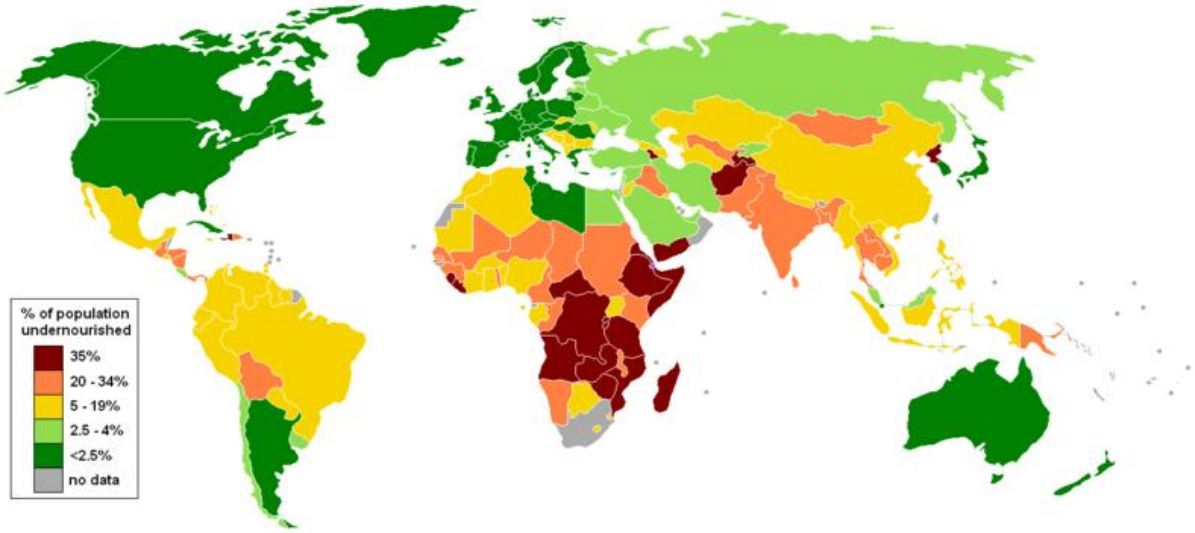


Figure 17: Prevalence of undernutrition worldwide (percentage of population)

Yemen is facing one of the world's worst humanitarian crises, with over two-thirds of the population in need of humanitarian assistance. The ongoing conflict, economic collapse, and restricted access to food and healthcare have led to high rates of undernutrition among children in Yemen

Yemen is facing a severe undernutrition crisis, with an estimated 16.2 million people experiencing food insecurity and 5 million facing severe food insecurity. Among children under five years old, 2.3 million suffer from acute malnutrition and 400,000 who are severely malnourished and at risk of death without urgent treatment and in 2013 estimated 750,000 Pregnant and lactating women are undernutrition (OCHA, 2020).

The prevalence of underweight in children under 5 years old was increased from 33.4% in 2000 to 46.6% in 2013. Also, as the conflict broken out in 2015 the children nutritional state worsened increasingly and in 2020 the prevalence of underweight reached to 50.7%. In 2020 according to the UN report 46% of children under five years old in Yemen are stunted, 18% of children under five years old are wasted, and 30% of children under five years old underweight with some areas reporting rates as high as 40% (UNICEF, 2020).

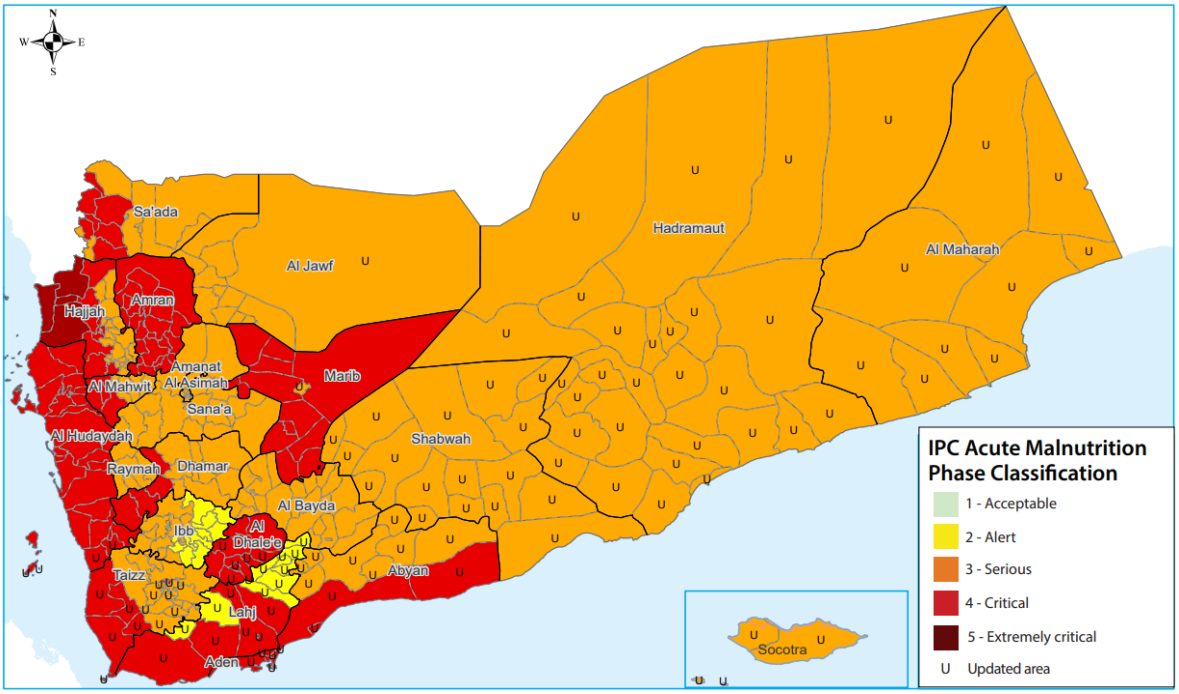


Figure 18: IPC acute malnutrition phase classification in Yemen

The stunting was significantly higher among children from rural areas compared to those from urban areas. Also, children from household with low socioeconomic status were more likely to be stunted than those from household with higher socioeconomic status (Al-Akhfash A.A et al., 2017); Furthermore, the prevalence of stunting was higher among male children compared to female children and significantly higher among children who were not breastfeed or were breastfeed for less than six months (Al-Sonboli et al., 2018).

Micronutrient deficiencies are also prevalent in Yemen due to poor dietary diversity and lack of access to essential vitamins and minerals, more than half (53%) of women aged 15-49 years old have anemia, which is a common indicator of iron deficiency (Al-Fakih R. et al., 2019).

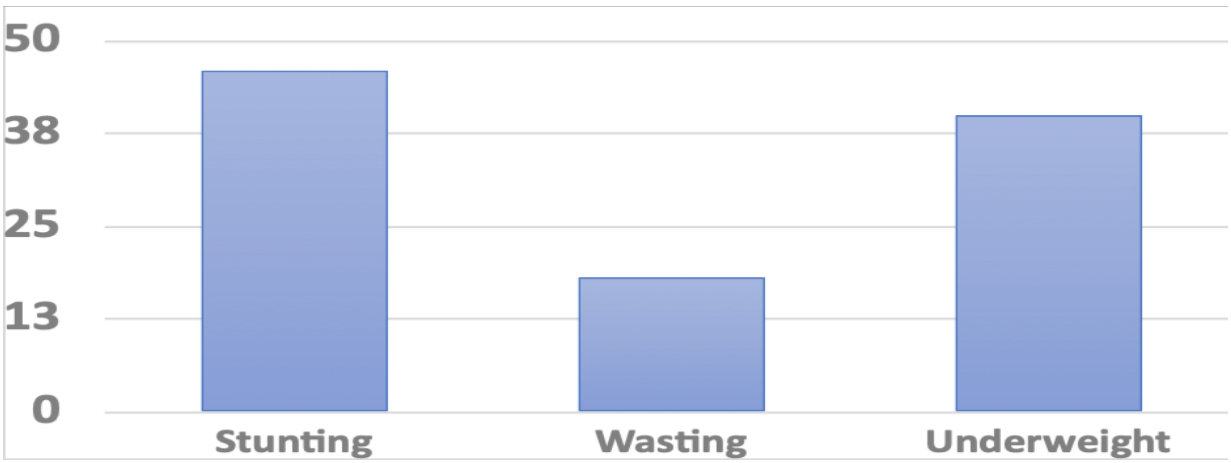


Figure 19: Prevalence of the different types of undernutrition among the children under age of 5 years in Yemen according to UN report in 2020

Pathophysiology of undernutrition

Inadequate energy intake leads to various physiologic adaptations, including growth restriction, loss of fat, muscle, and visceral mass, reduced basal metabolic rate, and reduced total energy expenditure (Grover Z. et al., 2009; Koletzko B., 2015; Ahmed T., 2012) The biochemical changes in acute malnutrition involve metabolic, hormonal, and mechanisms that regulate glucose. The main hormones affected are the thyroid hormones, insulin, and the growth hormone (GH). Changes include reduced levels of triiodothyronine (T3), insulin, insulin-like growth factor-1 (IGF-1) and raised levels of GH and cortisol (Grover Z. et al., 2009).Glucose levels are often initially low, with depletion of glycogen stores. In the early phase there is rapid gluconeogenesis with resultant loss of skeletal muscle caused by use of amino acids, pyruvate and lactate. Later there is the protein conservation phase, with fat mobilization leading to lipolysis and ketogenesis (Chowdhury M.S.I. et al., 2008; Ferdous T. et al., 2009; Batool R. et al., 2015). Major electrolyte changes including sodium retention and intracellular potassium depletion can be explained by decreased activity of the glycoside-sensitive energy-dependent sodium pump to increased permeability of cell membranes in kwashiorkor (Batool R. et al., 2015).

Organ systems are variably impaired in acute malnutrition (Grover Z. et al., 2009; Batool R. et al., 2015). Cellular immunity is affected because of atrophy of the thymus, lymph nodes, and tonsils. There are reduced cluster of differentiation (CD) 4 with normal CD8-T lymphocytes, loss of delayed hypersensitivity, impaired phagocytosis, and reduced secretory immunoglobulin A. Consequently, the susceptibility to invasive infections (urinary,

gastrointestinal infections, septicemia, etc.) is increased (Batool R. et al., 2015; Fischer Walker et al., 2012).

Villous atrophy with resultant loss of disaccharidases, crypt hypoplasia, and altered intestinal permeability results in malabsorption. Other common aspects are bacterial overgrowth and pancreatic atrophy resulting in fat malabsorption; fatty infiltration of the liver is also common (Grover Z et al., 2009).

Cardiac myofibrils are thinned with impaired contractility. Cardiac output is reduced proportionate to weight loss. Bradycardia and hypotension are also common in severe cases (Grover Z et al., 2009; Fischer Walker et al., 2012). The combination of bradycardia, impaired cardiac contractility, and electrolyte imbalances predisposes to arrhythmias. Reduced thoracic muscle mass, decreased metabolic rate, and electrolyte imbalances (hypokalemia and hypophosphatemia) may result in decreased minute ventilation and impaired ventilator response to hypoxia (Grover Z et al., 2009; Fischer Walker et al., 2012; Mamoun N. et al., 2005).

Acute malnutrition has been recognized as causing reduction in the numbers of neurons, synapses, dendritic arborizations, and myelinations, all of which resulting in decreased brain size. The cerebral cortex is thinned and brain growth slowed. Delays in global function, motor function, and memory have been associated with malnutrition (Georgieff M.K., 2007). The effects on the developing brain may be irreversible after the age of 3–4 years (Koletzko B., 2015).

Metabolic changes in severe malnutrition

Reduced secretion of insulin contributes to a catabolic state in both kwashiorkor (part a) and severe wasting (part b). In severe wasting, the reduced secretion of insulin leads to a lipolytic and proteolytic response and the release of free fatty acids (FFAs) and amino acids into the bloodstream. FFAs are taken up by muscle tissue for oxidation. Both FFAs and amino acids are also partially taken up by the liver and are used for ATP production and the synthesis of essential proteins and glucose. In kwashiorkor, this adaptive response is disturbed, which causes a reduced release of FFAs from adipose tissue and amino acids from muscle tissue. Mitochondrial damage in the liver is associated with increased reactive oxygen species (ROS) production and reduced glutathione. Arrow thickness represents the amount of metabolites in that pathway. TGs, triglycerides (Lewis B. et al., 1966).

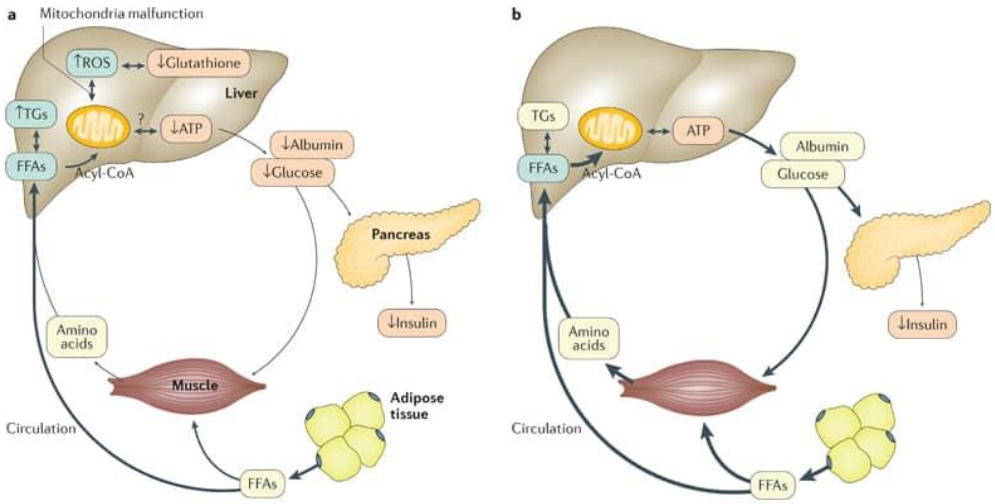


Figure 20: Metabolic changes in severe malnutrition

Kwashiorkor

Despite longstanding knowledge of kwashiorkor, the underlying pathophysiological mechanisms are poorly understood (Williams CD., 1933). However, few studies have identified any specific nutritional deficiencies associated with the development of kwashiorkor, and studies typically have not revealed major differences in food group intake between children who developed kwashiorkor compared with those who did not or with those who developed wasting (Laditan AA, Reeds PJ, 1976; Sullivan J. et al. 2006). Despite numerous hypotheses, the aetiology of oedema, which is the hallmark of kwashiorkor, remains undefined. In animal models, some features of kwashiorkor, such as hypoalbuminemia, can be induced by a diet low in protein and high in monosaccharides and disaccharides (Coulthard, MG., 2015; Coward DG, Whitehead RG. et al. 1972) but oedema is rarely observed. In addition, the degree of hypoalbuminemia and recovery upon nutritional management in children with kwashiorkor correlates poorly with the degree of oedema or the speed of its resolution (Golden MH et al. 1980). Thus, controversy remains regarding the contribution of factors other than hypoalbuminemia to the development of oedema in individuals with kwashiorkor (Coulthard MG. 2015; Golden MH., 1998).

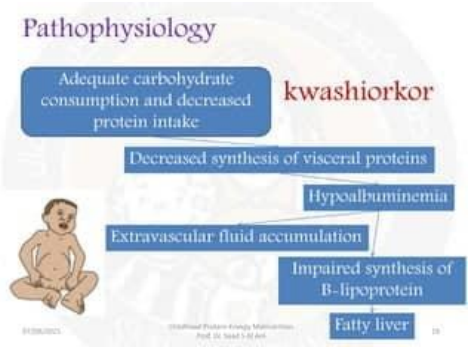
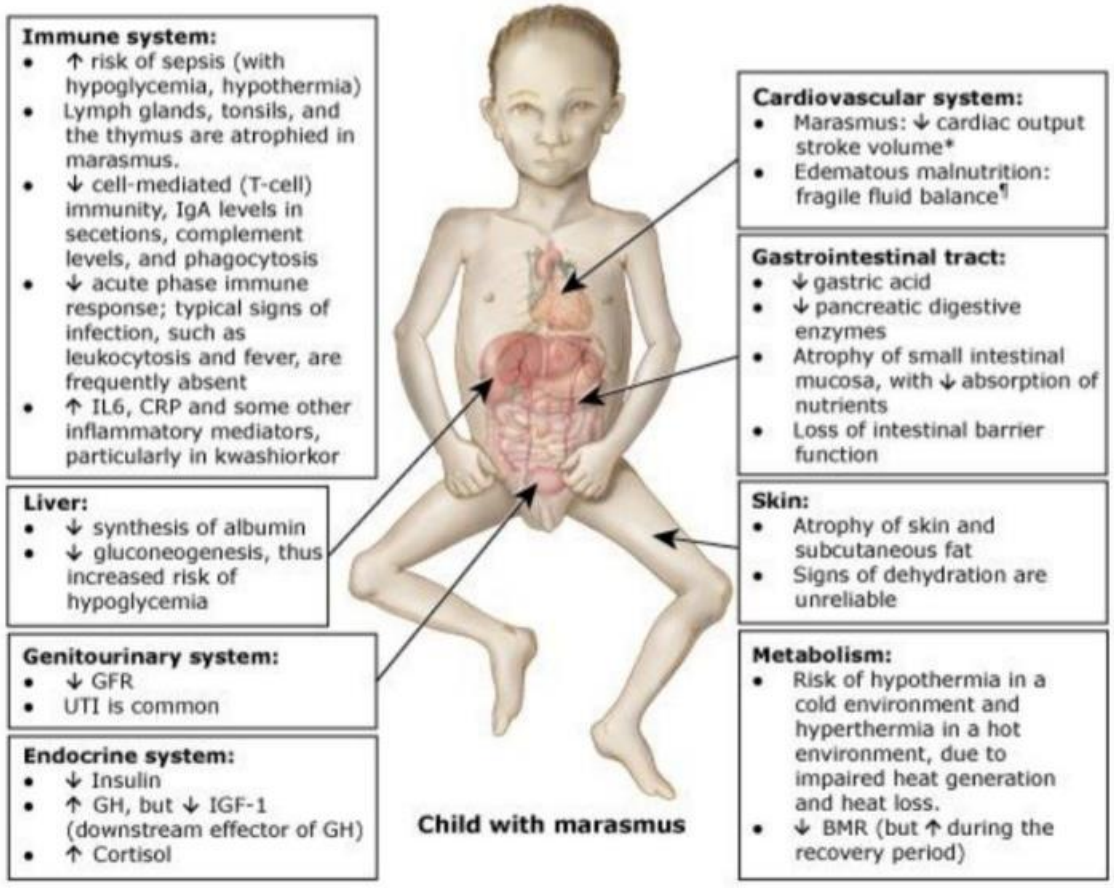
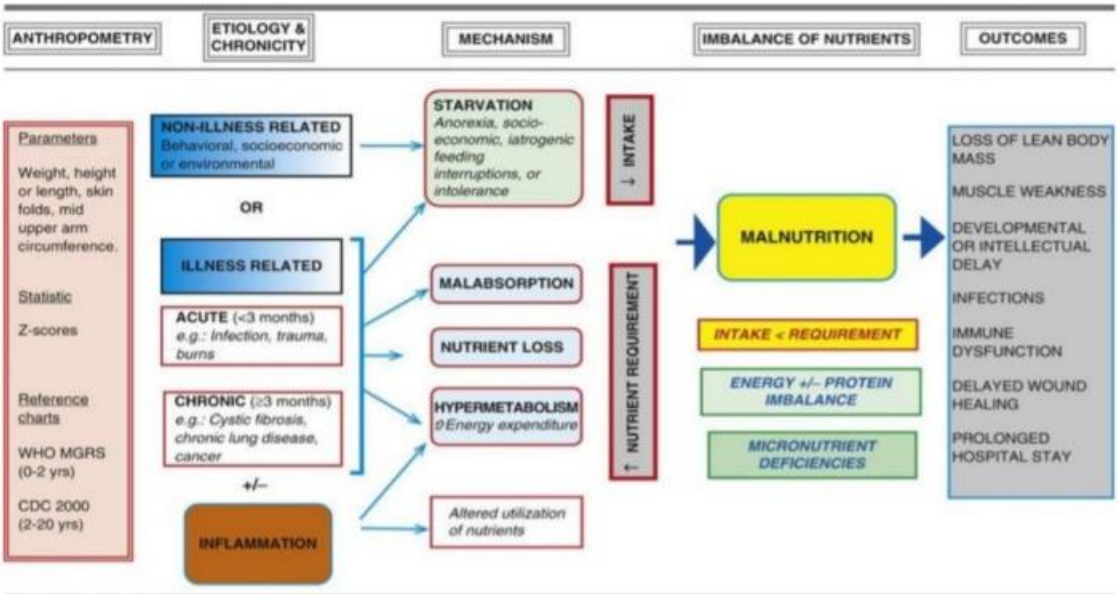


Figure 21: Pathophysiology of Kwashiorkor

Figure 22: Stomatitis due to kwashiorkor and vitamin B deficiency


Immune system:
• ↑ risk of sepsis (with hypoglycemia, hypothermia)
• Lymph glands, tonsils, and the thymus are atrophied in marasmus.
• ↓ cell-mediated (T-cell) immunity, IgA levels in secetions, complement levels, and phagocytosis
• ↓ acute phase immune response; typical signs of infection, such as leukocytosis and fever, are frequently absent
• ↑ IL6, CRP and some other inflammatory mediators, particularly in kwashiorkor
Liver:
• ↓ synthesis of albumin
• ↓ gluconeogenesis, thus increased risk of hypoglycemia
Genitourinary system:
• ↓ GFR
• UTI is common
Endocrine system:
• ↓ Insulin
• ↑ GH, but ↓ IGF-1 (downstream effector of GH)
• ↑ Cortisol
Child with marasmus
Cardiovascular system:
• Marasmus: ↓ cardiac output stroke volume*
• Edematous malnutrition: fragile fluid balance¶
Gastrointestinal tract:
• ↓ gastric acid
• ↓ pancreatic digestive enzymes
• Atrophy of small intestinal mucosa, with ↓ absorption of nutrients
• Loss of intestinal barrier function
Skin:
• Atrophy of skin and subcutaneous fat
• Signs of dehydration are unreliable
Metabolism:
• Risk of hypothermia in a cold environment and hyperthermia in a hot environment, due to impaired heat generation and heat loss.
• ↓ BMR (but ↑ during the recovery period)



. Muscle wasting

1. Calorie deficiency ⇒fats and tissue proteins mobilized to supply energy for metabolic processes
2. Recurrent infections coupled with hypoglycemia cause acute stress response ⇒ cortisol released ⇒ wasting
3. Effects of associated infections eg. HIV wasting syndrome, tuberculosis

Figure 23: Pathophysiology of marasmus

Clinical picture of Undernutrition

Undernutrition has lasting adverse consequences

Early childhood stunting is associated with poor cognitive, motor, linguistic, and socio-emotional skills, low IQ and undesirable educational outcomes (Nahar, B., Hossain,2019), reduced enthusiasm and increased apathy (Walker, S.P., Chang, S.M., Powe,2005), pregnancy-related complications, and birth to smaller babies among women in their later life (Walker, S.P,1999)

Childhood wasting increases the risk of lower respiratory infection-related under-5 mortality and is associated with a rise in blood pressure and poor educational outcomes. (Black, R.E., Allen, L.H., Bhutta, Z.A,2008).

Childhood underweight is associated with a compromised immune system, increasing the risk of infections, higher risk of fractures and osteoporosis, and fertility-related issues such as failed conception and pregnancy-related problems, and hormonal imbalance and menstruation problems (Asiki, G,2019)

Symptoms and signs of undernutrition in adults

The most common symptom is a notable weight loss. For example, those who have lost more than 10% of their body weight in the course of three months and are not dieting could be malnourished. Using the body mass adults. BMI below the 18.5 indicate malnourished status.(News-Medical.net,2012)

Also, Weakness of muscles and fatigue. The muscles of the body appear to waste away and may be left without adequate strength to carry out daily activities. Many people complain of tiredness all day and lack of energy. This may also be due to anemia caused by malnutrition. Increased susceptibility to infections. Delayed and prolonged healing even small wounds and cuts. Irritability and dizziness. Skin and hair becomes dry. Skin may appear dry, and flaky and hair may turn dry, lifeless, dull and appear like straw. Nails may appear brittle and break easily. Some patients suffer from persistent diarrhea or long term constipation.(News-Medical.net ,2012)

Other symptoms include, an inability to stay warm, diarrhea, loss of appetite, irritability, and apathy. In very severe cases, people may become unresponsive (called stupor). In women, menstrual periods become irregular or stop. If undernutrition is severe, fluid may accumulate in the arms, legs, and abdomen.(MSD Manual Professional Edition,2021)

Symptoms and signs of undernutrition in children include

- Growth failure

  This may be manifested as failure to grow at a normal expected rate in terms of weight, height or both. Irritability, sluggishness and excessive crying along with behavioral changes like anxiety, attention deficit are common in children with malnutrition. Muscle wasting and lack of strength in the muscles. Limbs may appear stick-like (News-Medical.net,2012).

- Swelling of the abdomen and legs

  The abdomen is swollen because of lack of strength of the muscles of the abdomen. This causes the contents of the abdomen to bulge out making the abdomen swollen. Legs are swollen due to edema. This is caused due to lack of vital nutrients. These two s symptoms are seen in children with severe malnutrition.(News-Medical.net,2012)

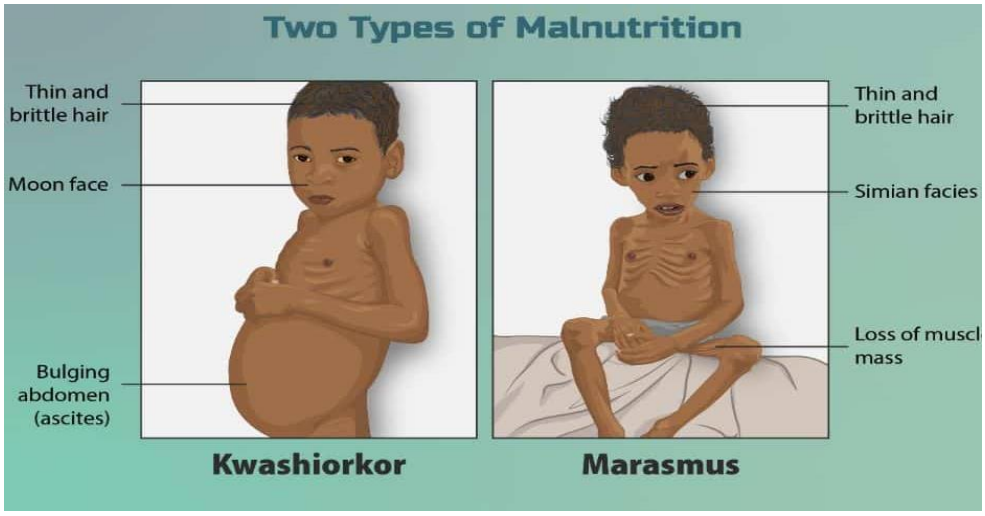


Figure 24: Types of malnutrition; kwashiorkor and marasmus

People starve for about 1 month, they lose about one fourth of their body weight. If starvation continues for a longer time, adults can lose up to half of their body weight and children can lose even more. Bones protrude, and the skin becomes thin, dry, inelastic, pale, and cold. Eventually, fat in the face is lost, causing the cheeks to look hollow and the eyes to seem sunken. The hair becomes dry and sparse, falling out easily.(MSD Manual Professional Edition,2021). Children who are severely undernourished may not grow normally. Behavioral development may be markedly slow, and mild intellectual disability may develop and continue until at least school age (MSD Manual Professional Edition,2021).

There are classically two types of protein energy malnutrition (PEM) in children. These are Marasmus and Kwashiorkor. In Marasmus there may be obvious weight loss with muscle wasting. There is little or no fat beneath the skin. The skin folds are thin and the face appears

pinched like an old man or monkey. Hair is sparse or brittle. In Kwashiorkor the child is with hair changing color to a listless red, grey or blonde. Face appears round with swollen abdomen and legs. Skin is dry and dark with splits or stretch marks like streaks where stretched. In nutritional dwarfism the patient appears stunted in growth.

Effects of malnutrition on every organ system

Muscle function

Weight loss due to depletion of fat and muscle mass, including organ mass, is often the most obvious sign of malnutrition. Muscle function declines before changes in muscle mass occur, suggesting that altered nutrient intake has an important impact independent of the effects on muscle mass. Similarly, improvements in muscle function with nutrition support occur more rapidly than can be accounted for by replacement of muscle mass alone.(Saunders, J. and Smith, T, 2010) .Downregulation of energy dependent cellular membrane pumping, or reductive adaptation, is one explanation for these findings. This may occur following only a short period of starvation. If, however, dietary intake is insufficient to meet requirements over a more prolonged period of time the body draws on functional reserves in tissues such as muscle, adipose tissue and bone leading to changes in body composition. With time, there are direct consequences for tissue function, leading to loss of functional capacity and a brittle, but stable, metabolic state. Rapid decompensation occurs with insults such as infection and trauma. Importantly, unbalanced or sudden excessive increases in energy intake also put malnourished patients at risk of decompensation and refeeding syndrome.(Jackson, A. A,2010)

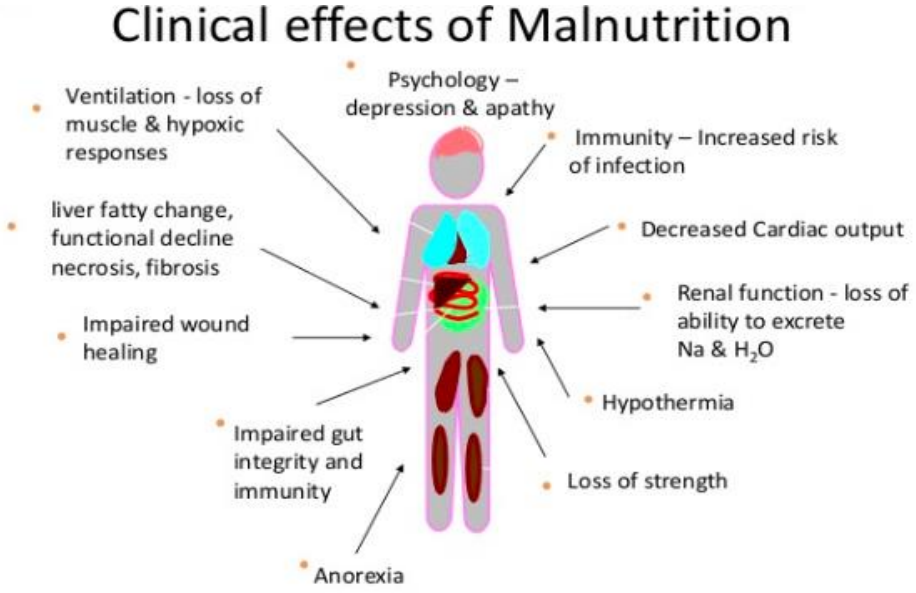

Clinical effects of Malnutrition
Ventilation - loss of muscle & hypoxic responses
Psychology – depression & apathy
Immunity – Increased risk of infection
liver fatty change, functional decline necrosis, fibrosis
Decreased Cardiac output
Renal function - loss of ability to excrete Na & H_2O
Impaired wound healing
Hypothermia
Impaired gut integrity and immunity
Loss of strength
Anorexia

Figure 25: Clinical effects of malnutrition

Cardio-respiratory function

Reduction in cardiac muscle mass is recognized in malnourished individuals. The resulting decrease in cardiac output has a corresponding impact on renal function by reducing renal perfusion and glomerular filtration rate. Micronutrient and electrolyte deficiencies (eg thiamine) may also affect cardiac function, particularly during refeeding. Poor diaphragmatic and respiratory muscle function reduces cough pressure and expectoration of secretions, delaying recovery from respiratory tract infections.(Saunders, J. and Smith, T, 2010)

Gastrointestinal function

Adequate nutrition is important for preserving GI function: chronic malnutrition results in changes in pancreatic exocrine function, intestinal blood flow, villous architecture and intestinal permeability. The colon loses its ability to reabsorb water and electrolytes, and secretion of ions and fluid occurs in the small and large bowel. This may result in diarrhoea, which is associated with a high mortality rate in severely malnourished patients(Jackson, A. A,2010).

Immunity and wound healing

Immune function is also affected, increasing the risk of infection due to impaired cell-mediated immunity and cytokine, complement and phagocyte function. Delayed wound healing is also well described in malnourished surgical patients.(Jackson, A. A,2010)

Psychosocial effects

In addition to these physical consequences, malnutrition also results in psychosocial effects such as apathy, depression, anxiety and self-neglect.

Risk factors of undernutrition

In the development of undernutrition, the starting point is reduction in dietary intake. This can be due to psychiatric illness, anorexia associated with infection, liver disease, neoplasm, drug interactions, nutrient deficiency, famine or starvation upper intestinal disease, malabsorption or other losses from the body.

Many observational studies on the relationship of undernutrition and infectious diseases have been done and have been extensively reviewed. This reduced dietary intake in turn leads to reduced mass, reduced requirements, reduced work, reduced physiologic and metabolic changes, changes in body composition and loss of tissue reserve. The defects become self-

reinforcing in vicious cycles. Leading to development of frank undernutrition and ultimately death. An example of such a vicious cycle is illustrated in figure 1.

Malnourished children are more prone to frequent long lasting and severe episodes of diseases that result in reduced dietary intakes due to reduction in appetite, nutrition loss, malabsorption and altered metabolism. The reduced dietary intake leads to further undernutrition therapy completing the cycle which starts again and if unbroken may quickly lead to death.

There are three levels of risk factors of undernutrition. Immediate causes operating at the individual level (biological risk factors), underlying causes operating at the household level (behavioral risk factors) and basic causes which operate at the social level (social risk factors). The biological risk factors include infectious diseases such as diarrhea, gastroenteritis, intestinal and urinary helminthes, respiratory tract infection and pneumonia, malabsorptive status and chronic illnesses such as crohn's disease, coeliac disease, anorexia nervosa and bariatric surgery can cause undernutrition.

The behavioral risk factors include poor water and sanitation, inappropriate maternal and infant feeding practices, inappropriate breastfeeding and complementary feeding practices of the infant, insufficient access to food and driving too much of the diet from single source of food.
The social risk factors include political, cultural and religious factors such as poor education, low socioeconomic status and poverty, food shortages and insecurity and finally famine (Young EM, 2012)

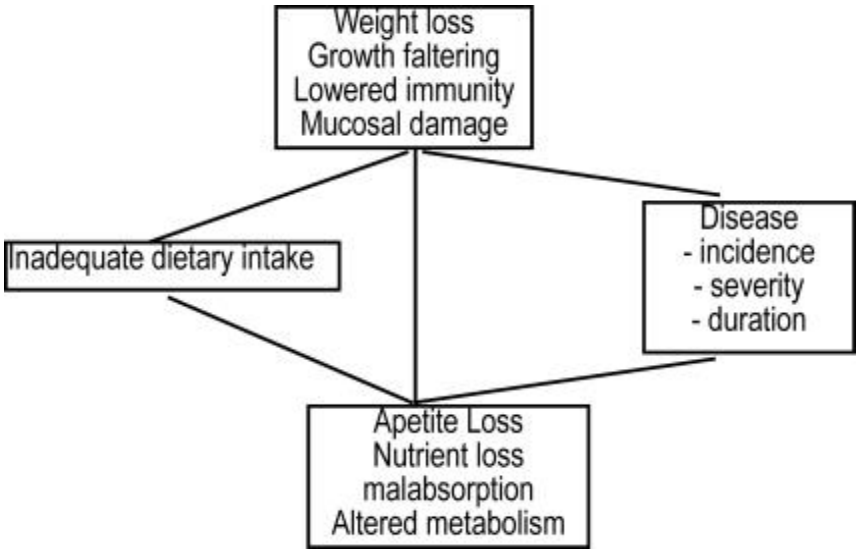


Figure 26: inadequate dietary intake disease cycle

Diagnosis of Undernutrition

Diagnosis of undernutrition is typically made by a healthcare professional using a combination of physical examination, medical history, and sometimes laboratory blood test. Doctors can usually diagnose undernutrition by asking questions about diet and weight loss and by doing a physical examination. Severe, long-standing undernutrition can usually be diagnosed based on the person's appearance and history (Morley J.E., 2017)

The commonly used anthropometric measures are weight and length (height) in combination with age and sex. These measurements are used to construct indices and indicators that are used to describe nutritional status of individuals or populations. Other measures of body composition that are used include various body circumferences (mid upper arm, head, chest, abdomen etc) and skin folds (biceps, triceps, sub-scapular etc).

Three basic indices are used in childhood: weight for age Z score (WAZ), length / height for age Z score (LAZ / HAZ) and weight for length / height Z score (WLZ / WHZ) (Waterlow JC., 1976).

- Weight for age: defined as weight of a child relative to the weight of a child of the same age in a reference population, expressed either as a Z score or a percentage relative to the median of the reference population. Qualitatively children who have low weight for age are described as being ‘underweight’.
- Height for age (/ length for age): defined as height or length of a child relative to the length or height of a child of the same age in a reference population, expressed either as a Z score or a percentage relative to the median of the reference population. Qualitatively children who have low height for age are described as being ‘stunted’.
- Weight for height (/ weight for length): defined as weight of a child relative to the weight of a child of the same height or length in a reference population, expressed either as a Z score or a percentage relative to the median of the reference population. Qualitatively children who have low weight for height are described as being ‘wasted’. Wasting is also sometimes called global undernutrition or global acute malnutrition (GAM). Table 1 shows how the indices are used to define undernutrition. (Waterlow JC, 1976)

		Normal	Mild*	Moderate*	Severe*
Weight for height (wasting)	%+ Z score	90 – 120 2.0 to −0.99	80 – 89 −1 to −1.99	70 –79 −2.0 to −2.99	< 70% <−3.0
Height for age	%	95 – 110	90 – 94	85 – 89	< 85
(stunting)	Z score	2.0 to −0.99	−1.0 to −1.99	−2.0 to −2.99	< −3.0

Table 6: Waterlow's classification of undernutrition

- Without oedema. Presence of oedema denotes severe malnutrition (kwashiorkor) even without severe wasting (Marasmus).
- + Percentage of the median World Health Organization (WHO) / United States National Centre for Health Statistics (NCHS) reference.

As part of the physical examination, doctors do the following:

- Determine the body mass index (BMI).
- Estimate the amount of muscle and fat in the mid upper arm by measuring the circumference of the upper arm and the thickness of a fold of skin on the back of the left upper arm (triceps skinfold).
- Check for other symptoms that may indicate undernutrition (such as changes in the skin and hair and accumulation of fluid in the limbs or abdomen).What they find helps them confirm the diagnosis and determine how severe undernutrition is (Morley J.E., 2017)

Mid-upper arm diameter

Mid upper arm diameter may be used in children. An upper arm circumference of less than 110 mm is also used to define severe malnutrition in children. In children thickness of skin folds is also measured. With malnutrition there is loss of the fat beneath the skin called the subcutaneous fat. This leads to thin skin folds (News-medical.net, 2012)

Note the percentage of unplanned weight loss and provide a score. For example, an unplanned loss of 5–10% would give a score of 1, while a 10% loss would score a 2.
Identify any mental or physical health conditions and provide a score. For example, if a person has been acutely ill and taken no food for over 5 days, this would lead to an additional 2 points (Brazier Y., 2020)

Medical history

A healthcare professional will ask about your eating habits, any recent weight changes, and any medical conditions that could contribute to undernutrition, such as gastrointestinal disorders or cancer (Morley J.E., 2017)

Testing

Whether tests are done depends on the circumstances. For example, if the cause is obvious and can be corrected, tests are usually not needed.

The test most often done is a blood test to measure the level of albumin (which decreases when people do not consume enough protein). Doctors may also measure the number of certain types of white blood cells (which decreases as undernutrition worsens).

Skin tests may be done to check how well the immune system is functioning. A substance that contains an antigen (which normally triggers an immune reaction) is injected under the skin. If a reaction occurs within a certain amount of time, the immune system is functioning normally. A delayed reaction or no reaction indicates a problem with the immune system, which may be due to undernutrition.

If doctors suspect a vitamin or mineral deficiency, blood tests to measure levels of those nutrients are usually done. If doctors suspect the cause is another disorder, other tests may be done to help identify the cause. For example, if people have diarrhea that is severe or persists despite treatment, doctors may check a sample of stool for microorganisms that can cause infection. Tests, such as urine tests and chest x-rays, may be done to look for infections (Morley J.E., 2017)

Blood tests in children

Routine blood tests in children include those for blood glucose, blood counts, urine for routine examination, stool for parasites and worm infestations (as these may lead to malnutrition in children), blood protein or albumin levels, HIV test and tests for other infections.
Levels of iron in blood, folic acid and vitamin B 12 are also recommended. For protein estimation other tests include Pre-albumin, transferrin, retinol-binding protein (news-medical.net, 2012)

Other tests for undernutrition including:

- Thyroid function tests
- Estimation of the intestine for Crohn’s disease or Coeliac disease

- Levels of Calcium, Phosphate, Zinc and vitamins
- Low levels of cholesterol and albumin (especially in elder) (news-medical.net, 2012)

Management of undernutrition

Treatment for malnutrition (undernutrition) may involve:

- Dietary changes

  Such as eating foods high in energy and nutrients support for families to help them manage factors affecting the child's nutritional intake
- Treatment for any underlying medical conditions causing malnutrition
  1. Vitamin mineral supplements
  2. High-energy and protein nutritional supplements – if the other treatments are not enough on their own
  3. Severely malnourished children need to be fed and rehydrated with great care. They cannot be given a normal diet immediately. They'll usually need special care in hospital.

Overview of management of severe and moderate malnutrition

The first step in the treatment of malnutrition is to determine the severity:

- Moderate malnutrition

  It is typically treated with the use of supplementary foods, which are administered in addition to the child's normal diet.
- Uncomplicated severe malnutrition

  It is usually treated with
  1. ready-to-use therapeutic foods (RUTFs): they are given instead of the child's normal diet,
  2. a course of oral antibiotics and along with other treatments, such as deworming and treatment for other non-life-threatening infections.

Notes:

1. The management of complicated severe malnutrition requires admission to an inpatient facility with adequate pediatric emergency care facilities and a nutritional rehabilitation care programs.
2. Children with complicated malnutrition can be discharged from inpatient facilities when serious complications have resolved, and subsequently entered into outpatient management programs.

Management includes the use of therapeutic foods and antibiotics and the treatment of other infections. After the completion of treatment for severe malnutrition, children are transitioned from RUTFs to their home diet, which is a potential point of faltering. However, aside from standardized supplementary feeding, strategies to decrease this risk have not been assessed in trials.

Management of severe acute malnutrition

The management of children with severe malnutrition has several components:

1. Therapeutic feeding with macronutrients and micronutrients to achieve homeostasis and overcome the nutrient deficits
2. The immediate identification and management of life-threatening infections and complications such as sepsis and metabolic derangements
3. The treatment of subclinical infections and underlying conditions, such as HIV or tuberculosis
4. The cognitive stimulation and emotional support of the child and psychosocial support for their parents or caregivers

Therapeutic foods

such as:

1. Ready-to-use therapeutic foods (RUTFs)

   As RUTFs provide individuals with nutrients at levels that are nearly impossible to reach, the direct assessment of the effect of RUTFs on weight gain 164 without supplementation compared with the effect of a local diet alone has not been carried out

Figure 27: Ready-to-use therapeutic foods

2. F-75 and F-100 milks:
   a. The formulations of F-75 and F-100 were derived and optimized based on metabolic studies of hospitalized children with severe malnutrition
   b. F-75 is used for initial refeeding and F-100 is effective in facilitating rapid catch-up weight gain but might not correct all of the metabolic disturbances in children with severe malnutrition

These are designed for nutritional and metabolic stabilization and rehabilitation.

Aims of usage

1. To address anticipated calorific needs
2. Treatment stage-appropriate protein, electrolyte and micronutrient requirements,
3. To initially limiting exposure to nutrients that could be harmful to metabolically unstable children or those with infections, such as sodium and iron. (Manary MJ et al., 2004)

Notes:

1. The precise nutrient requirements of children with severe malnutrition and the bioavailability of these therapeutic foods are not well established and might vary by setting and the presence of comorbidities in some patients.
2. Children treated with RUTFs have a higher proportion of recovery and weight gain than children who received a local diet supplemented with additional vitamins and minerals despite the benefits associated with use of therapeutics foods, a rapid increase in macronutrient and micronutrient intake can lead to some negative health consequences, and refeeding syndrome (Bandsma RH et al. 2011; Nyeko R et al., 2010) including diarrhoea (due to carbohydrate malabsorption)).

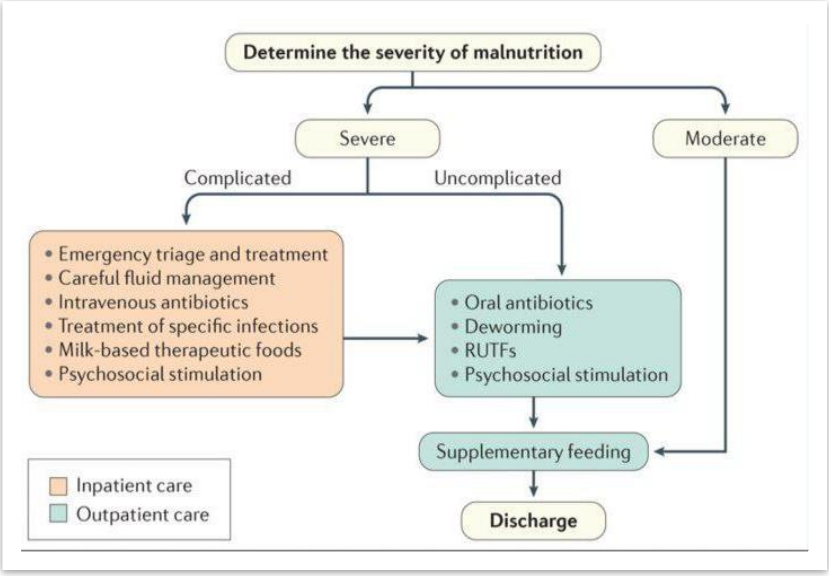


Figure 28: Guidelines for managing undernutrition

Prevention of undernutrition

Given the high morbidity and mortality associated with severe malnutrition, preventing it is one of the most important goals in global health. The best way to prevent malnutrition (including undernutrition) in WHO is eat a healthy, balanced diet. The health and vitality of human beings depend on a diet that includes adequate amounts of certain vitamins and minerals that promote effective functioning of physiologic processes

The prevention of undernutrition in pregnant women

Improved pregnant women feeding practices through:

- Dietary supplementation during pregnancy:
    1. Current evidence suggests that only supplements that provide more energy rather than more protein improve birth weight significantly.
    2. Maternal supplementation can increase maternal weight gain, infant head circumference and when there is a serious energy deficit, the length of the new born infant.

The prevention of undernutrition in infant and children

Improved infant and child feeding practices through:

- Promotion of breast-feeding

  It is a strategy that has been encouraged to prevent development of undernutrition.
- Improving complementary feeding
    1. Appropriate complementary feeding which should be introduced at optimal time can reduce the incidence of undernutrition.
    2. In most developing countries, the energy density of broths and gruels used as complementary feeds is below the recommended 0.6kcal/g. Energy density can be improved by reducing water content and providing additional feedings. At present there is insufficient evidence to support use of amylases to lower the viscosity of cereals and increasing energy through adding sugar and oil can adversely affect the density of protein and micronutrients in the diet.
- Supplementary feeding
    1. It is one of the commonest approaches to secondary prevention of undernutrition. It has been used for both prevention and treatment of undernutrition.
    2. In controlled research situations supplementary feeding has been shown to improve growth of undernourished children.
    3. Supplementary feeding in children has been associated with improvements in weight and height gain in controlled situations 51–53. The improvements in growth have however been more pronounced in children less than 2 years and have depended on the severity of undernutrition. This has been attributed to the fact that growth rates and incidence of undernutrition are highest in under-2-year-old children. As such, the often-short dietary supplementation interventions are likely to show effect on growth during such periods of high growth rates.

Notes:

Some important minerals and vitamins need to prevent undernutrition are:

1. Iron

   It is present in both heme and nonheme forms in the diet.

- Heme iron
    - The most bioavailable form, is found in the greatest quantities in animal sources such as red meat, eggs and all vegetable roots, seeds, leaves, and fruits.
    - Normal individuals absorb between 20 and 30 percent of dietary heme iron, while iron-deficient subjects absorb between 40 and 50 percent (Ministry of Health and Population, 2003)

2. Iodine
    - It must be obtained from the environment, but it has been depleted from the soil and water in many areas of the world.
    - WHO has estimated that over 1.5 billion persons in the world reside in regions of environmental iodine deficiency and are at risk of IDD (Ministry of Health and population, 1998)
3. Protein

    It is important in our life that we can find it in some foods include: lean meats, beef, lamb, chicken,fish and seafood , and eggs.
4. Vitamin A
    - It is found in fruits and vegetables that contain green and yellow provitamin A carotenoid pigments and as the preformed vitamin in liver and breast milk.
    - Humans need less than 1 milligram of vitamin A a day to maintain health

So, Micronutrient supplementation of iron / folate and iodine supplementation using community health workers to prevent the undernutrition and malnutrition

Prognosis

The prognosis of undernutrition depends on several factors, including the severity of the condition, underlying causes, and the presence of any co-morbidities. Early detection and intervention can significantly improve the prognosis of undernutrition, and addressing the patient's immediate nutritional needs and monitoring their long-term health and well-being are crucial components of the treatment plan (Bhutta Z. A. et al., 2008)

Patients with mild to moderate undernutrition generally have a good prognosis if the underlying cause is identified and addressed promptly. In many cases, dietary modifications, nutritional supplementation, and addressing any underlying medical conditions can lead to a complete recovery. However, if undernutrition is left untreated or becomes severe, it can lead to serious health complications and increase the risk of morbidity and mortality (WHO, 2022)

In severe cases, hospitalization and specialized nutrition support may be necessary. Patients with severe undernutrition may require enteral or parenteral nutrition to meet their nutritional needs. In these cases, the prognosis depends on the patient's response to treatment, the severity of their underlying medical conditions, and their overall health status. (WHO, 2022)

In some cases, undernutrition can have long-term effects on the patient's health and well-being, even after treatment. For example, undernutrition during early childhood can lead to stunted growth, impaired cognitive development, and increased susceptibility to infections. Long-term follow-up and monitoring of the patient's nutritional status are essential for preventing future occurrences of undernutrition and addressing any potential long-term effects. (Koletzko et a., 2022).

It is important to consider the patient's social determinants of health when assessing the prognosis of undernutrition. Patients with limited access to resources, housing instability, or financial constraints may have a more challenging prognosis due to ongoing barriers to accessing adequate nutrition. Addressing these social determinants of health may require a multidisciplinary approach, including collaboration with social workers, community resources, and public health initiatives. (López-Hernández, 2020)

In conclusion, the prognosis of undernutrition depends on several factors, including the severity of the condition, underlying causes, and the presence of any co-morbidities. Early detection and intervention are crucial for improving the prognosis of undernutrition and preventing its long-term effects on the patient's health. Addressing the patient's immediate nutritional needs and monitoring their long-term health and well-being can lead to better outcomes and reduce the risk of future occurrences of undernutrition (United Nations Children’s Fund, 2021)

Chapter 3

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Stunting

Stunting is one of the health problems in Yemen. It increases the risk of illness, irreversible body damage and mortality in children.

Definition of Stunting

Low height-for-age is known as stunting. It is the result of chronic or recurrent undernutrition, usually associated with poor socioeconomic conditions, poor maternal health and nutrition, frequent illness, and/or inappropriate infant and young child feeding and care in early life. Stunting holds children back from reaching their physical and cognitive potential. (WHO , 2021)

Stunting in Children

Stunting is a form of childhood undernutrition used to refer to population of children who are too short for their age and is an unambiguous sign of not developing well physically and mentally inside the first 1000 days (UNSEF,2019) from conception until the age of two. (WHO, 2015)

Figure 29: Stunting is low height-for-age

Children are defined as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median. (Vonaesch P et al ., 2017)

Stunting classification

When the z score standard deviations is below the median height for age, we can grade stunting According to WHO into:

1. Moderate Stunting: when z score equal or more than -3 and less than -2 (-3 ≤ z score <-2)
2. Sever stunting: when the z score is less than -3 (z score <-3) (KAREN J., 2023)

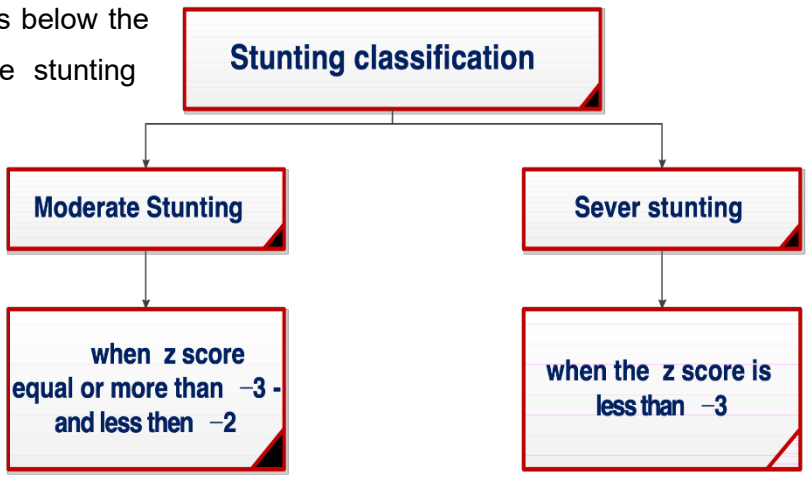

Stunting classification
Moderate Stunting
Sever stunting
when z score equal or more than −3 - and less then −2
when the z score is less than −3

Figure 30: Stunting classification

Causes of Stunting

- Stunting starts from pre-conception when an adolescent girl who later becomes mother is undernourished and anemic and it worsens when infants' diets are poor, and when sanitation and hygiene are inadequate.
- Stunting arises from a combination of poor food consumption, and poor health care, unhealthy environment, because urban regions have better health outcomes than rural regions in developing countries. For instance, rural children could be less healthy not only because they visit health care providers less frequently but also because health care providers at rural region are less effective, in addition, rural regions are characterized by lower access to electricity, sanitation and health care (Abdesslam B., 2012)

Figure 31: The cycle of stunting

- Low- and middle-income countries, is the result of the exposure of the fetus and/or young child to nutritional deficiencies and infectious diseases. Maternal undernutrition results in fetal growth restriction
- Infectious diseases in pregnancy can result in preterm delivery (Robert E Black et al., 2018; Christopher Duggan et al. 2013). Both of these conditions are important contributors to stunting in early childhood, albeit their relative contribution varies by world region. After birth, growth faltering may begin at 3-5 months of life and becomes more prominent from 6 to 18 months. During this time, the young child is exposed to many infectious diseases, such as diarrhea, that have an adverse effect on growth (Robert E Black et al., 2018).
- Defect in small bowel function early in infancy in developing countries are increasingly being demonstrated, probably. accompanied by altered mucosal architecture in most. individuals, including reduced enterocyte mass and evidence of immune activation and inflammation in the mucosa. These alterations appear to be the result of factors of uncertain nature in the environment, and may be a cause of growth faltering and stunting in young children. For these reasons, this constellation of findings is being referred to as environmental enteropathy, or as we propose herein, environmental enteric dysfunction (Christopher Duggan et al. 2013).

- Insufficient maternal nutrition before and during pregnancy, intrauterine undernutrition during pregnancy, lack of breastfeeding until 6 months of age because it is the age of rapid development, ((breastfeeding in the first 6 months of life reduces the chances of infants dying from diarrhoea, acute respiratory infections and other diseases that causes stunting (Dewey KG et al., 2011).

Stunting is a largely irreversible outcome of inadequate nutrition & repeated bouts of infection during the first 1,000 days of a child's life
Stunting has long-term effects, including: Diminished cognitive and physical development, reduced productive capacity and poor health
Stunted children have an increased risk of becoming overweight or obese later in life

Figure 32: An infographic showing the causes and long-term effects of stunting

- Age of first pregnancy is important because higher maternal age at first pregnancy had a protective effect against stunting. Regional variations, socio-economic disparities, and maternal education and health care utilization behavior are causes stunting in Yemeni children (Kencana Sari et al., 2021)

Epidemiology of Stunting

Stunting is one of the most significant impediments to human development, globally affecting approximately 162 million children under the age of 5 years. It is a largely irreversible outcome of inadequate nutrition and repeated bouts of infection during the first 1000 days of a child's life. Stunting has long-term effects on individuals and societies, including diminished cognitive and physical development, reduced productive capacity and poor health, and an increased risk of degenerative diseases such as diabetes. If current trends continue, projections indicate that 127 million children under 5 years will be stunted in 2025. Therefore, further investment and action are necessary to attain the 2025 World Health Assembly target of reducing that number.

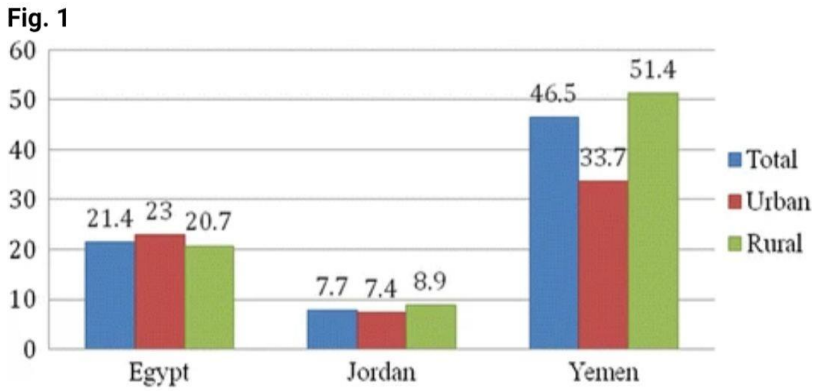


Figure 33: Children stunting in Egypt, Jordan and Yemen

The above figure depicts the aggregate, as well as the urban and rural, child stunting rates in Yemen, about one in every five children under five years old is stunted. However, the difference in stunting rates between rural and urban regions is not stark (2.3 %), with rural children have better nutritional status than their urban counterpart. In Yemen, the situation is catastrophic, and the country has substantial high malnutrition rates, with more than half of the Yemen under-5-years children are stunted. Figure.2 shows a significant difference, of about 17 %, in stunting rates between urban and rural. The overall prevalence of child stunting is quite low (less than 8 %), and the difference in stunting rates between the urban and rural regions is also small (1.5 %) with rural children are performing worse than urban.

The most top countries with respect to stunting prevalence are Burundi, Madagascar, Guatemala and Yemen (>46%) (Fig. 2, top panel). In contrast, Trinidad and Tobago, Dominican Republic, Jordan, and Armenia were at the bottom of countries with stunting prevalence (<10%).

Around 61% of the sample countries had intra-country lowest and highest stunting rate differences of 20% percentage points or more (Fig. 3). The highest intra-country stunting differences were found in Burundi (42%), Peru (45%), Guatemala (51%), and Nigeria (52%). The lowest intra-country stunting rates differences were found in Trinidad and Tobago (0%), Swaziland (7.2%), and Dominican Republic (7.3%) Moldova (7.5%) (Ssentongo P et al.,2019;WHO, 2018; WHO, 2021)

Notes:

1. DHS data set is publicly available online on the following link: https://dhsprogram.com/data/available-datasets.cfm

2. Notes: https://data.unicef.org/resources/world-breastfeeding-week-2020/

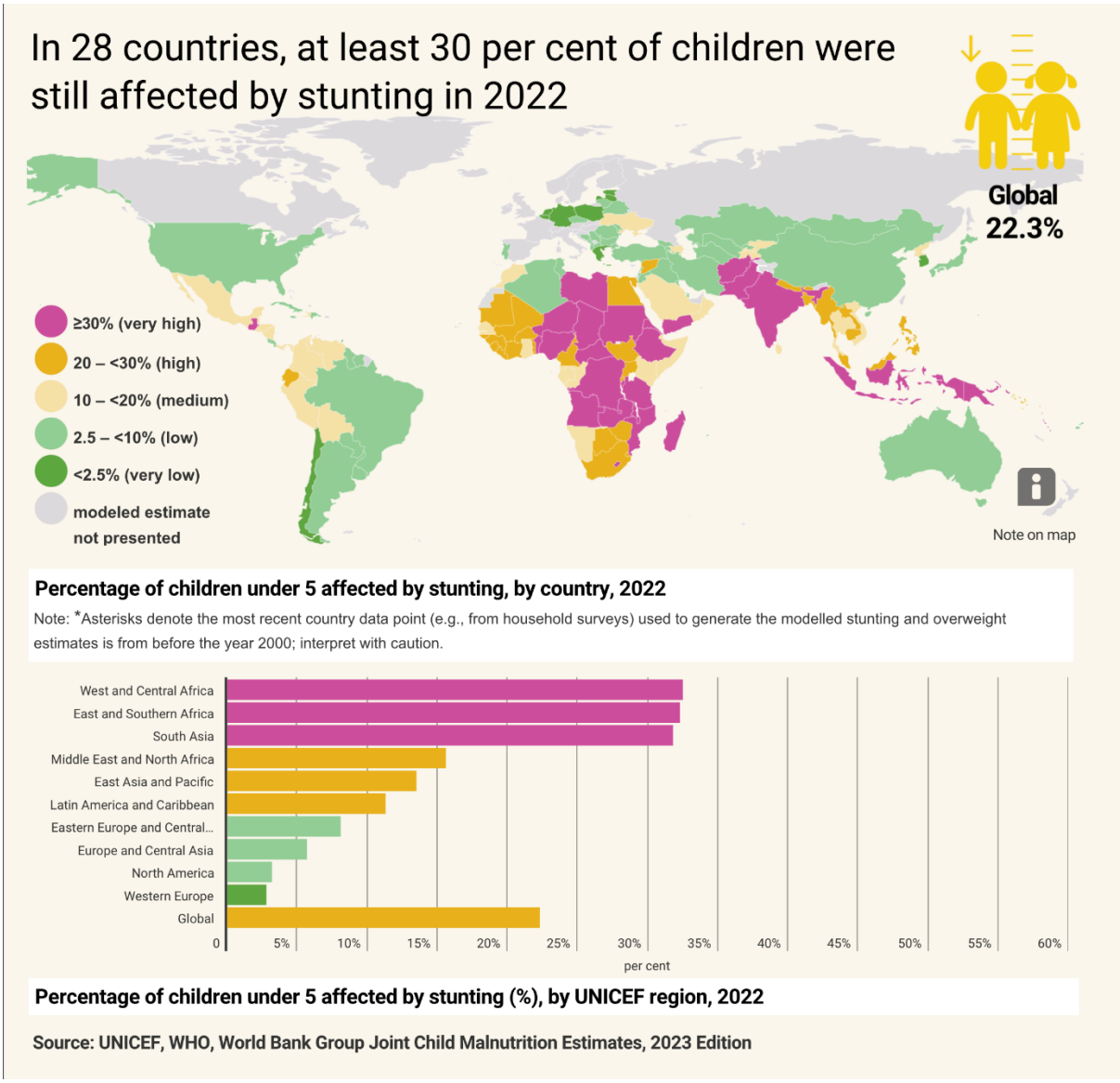
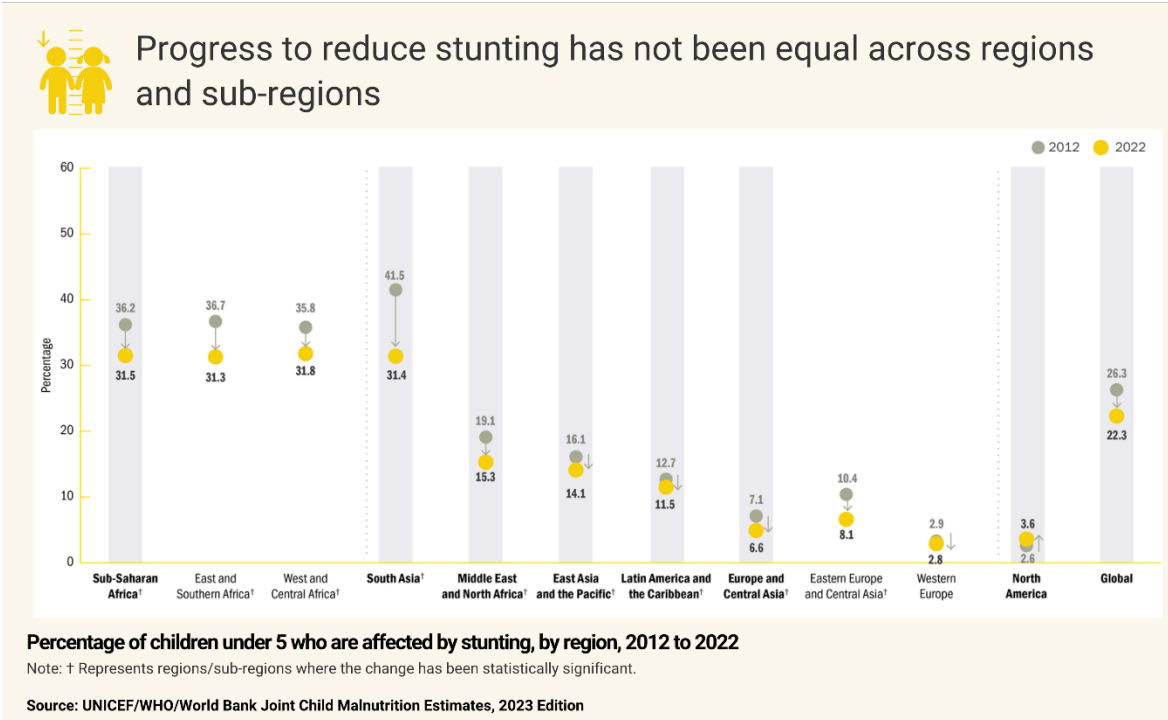

In 28 countries, at least 30 per cent of children were still affected by stunting in 2022
Global
22.3%
≥30% (very high)
20 – <30% (high)
10 – <20% (medium)
2.5 – <10% (low)
<2.5% (very low)
modeled estimate not presented
Note on map
Percentage of children under 5 affected by stunting, by country, 2022
Note: *Asterisks denote the most recent country data point (e.g., from household surveys) used to generate the modelled stunting and overweight estimates is from before the year 2000; interpret with caution.
West and Central Africa
East and Southern Africa
South Asia
Middle East and North Africa
East Asia and Pacific
Latin America and Caribbean
Eastern Europe and Central...
Europe and Central Asia
North America
Western Europe
Global
0
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
per cent
Percentage of children under 5 affected by stunting (%), by UNICEF region, 2022
Source: UNICEF, WHO, World Bank Group Joint Child Malnutrition Estimates, 2023 Edition

Figure 34: Percentage of children under 5 affected by stunting worldwide in 2022

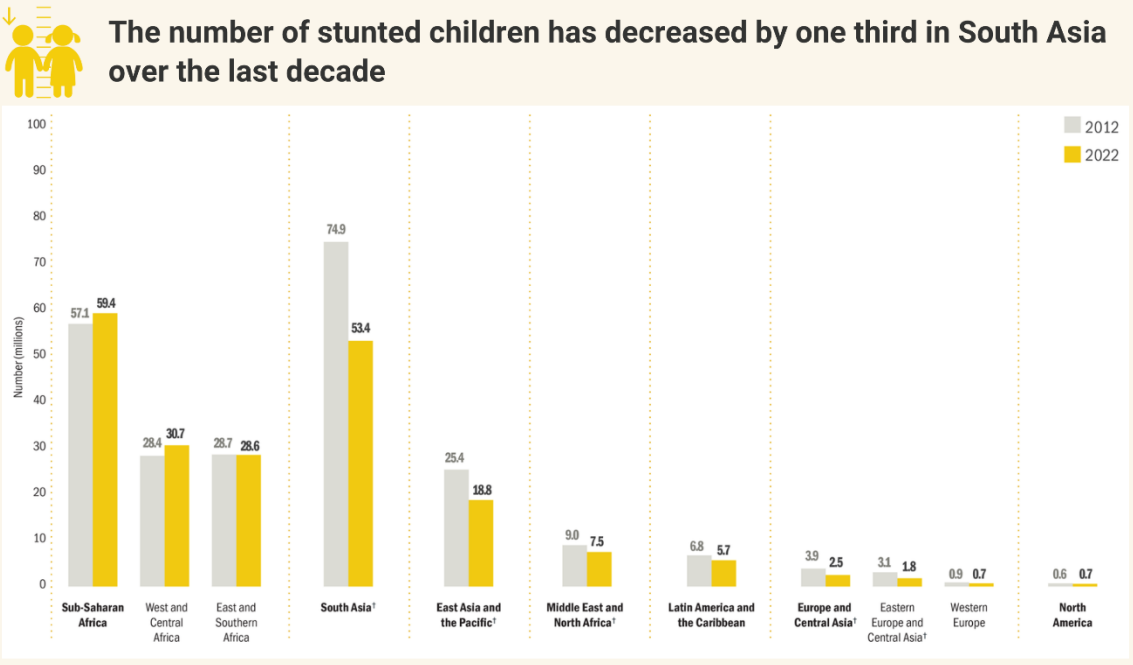


Percentage of children under 5 who are affected by stunting, by region, 2012 to 2022

Note: † Represents regions/sub-regions where the change has been statistically significant.

Source: UNICEF/WHO/World Bank Joint Child Malnutrition Estimates, 2023 Edition

Figure 35: Progress to reduce stunting hasn't been equal across regions and sub-regions



Trends in the number (millions) of children under 5 affected by stunting, by UNICEF region/sub-region, 2012 and 2022

Note: † Represents regions/sub-regions where the change has been statistically significant.

Source: UNICEF/WHO/World Bank Joint Child Malnutrition Estimates, 2023 Edition

Figure 36: Trends in the number of children (in millions) under 5 affected by stunting from 2012 – 2022, showing that southeast Asia has had the most decrease in the number of stunting (by one third)

Pathophysiology

The main pathophysiological underpinnings of stunting have not been fully investigated yet; more research is needed to draw a clearer picture of what the pathophysiology entails. With that being said, current research shows that the main tentative etiologies are maternal stunting and malnutrition, chronic inflammation, dysbiosis and environmental enteric dysfunction (EED), malnutrition, and deficiencies in micronutrients. Stunting has also been also associated with other distal factors that range from education and the lack of it, urbanization, political instability to population density and social support networks and the lack there of.

Maternal stunting and malnutrition has been consistently shown to cause stunting in newborns. Consequently, stunting and the effects that accompany it are intergenerational which lead some experts to suggest the notion of “stunted families” (Prendergast and Humphrey, 2014; Chusilp et al., 1992). An epigenetic component has been implicated in mediating the cross generational effects of stunting, as maternal diet has been shown to cause epigenetic changes in the fetus (McKay and Mathers, 2011).

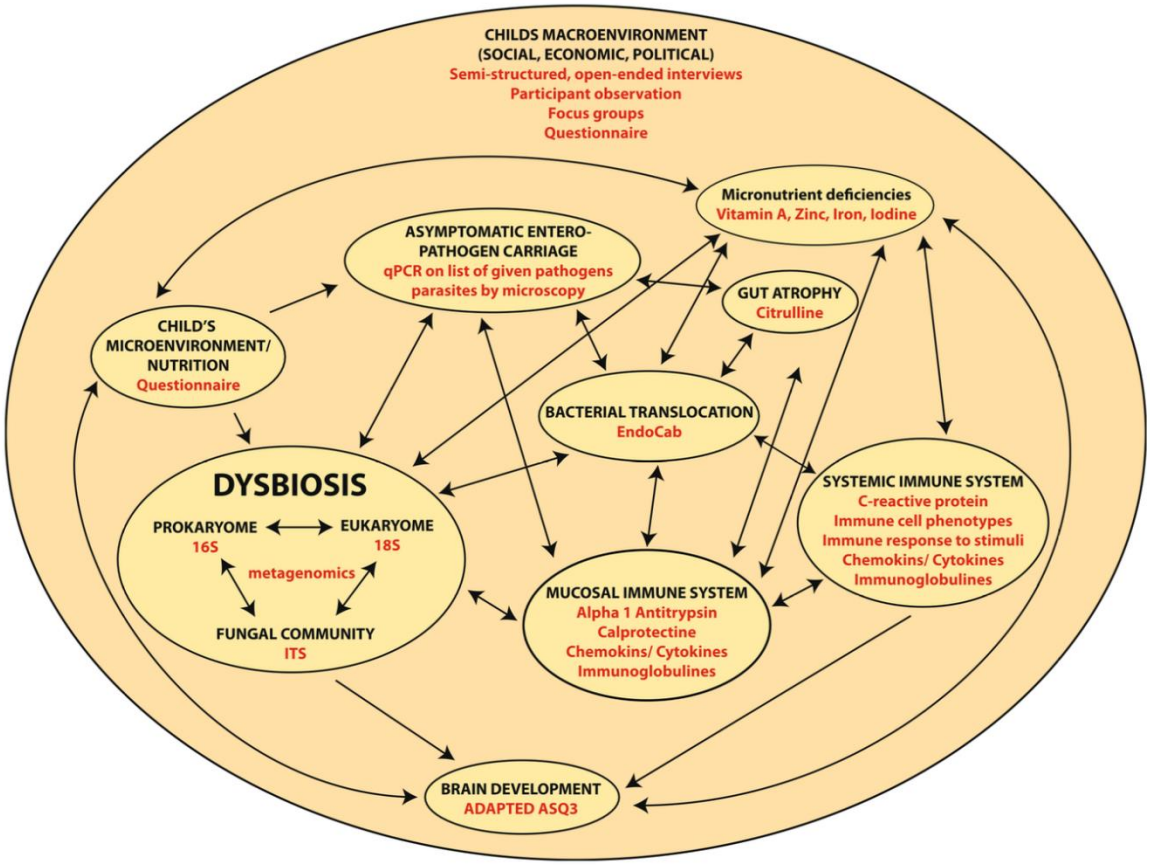


Figure 37: A scheme for the pathogenesis of EED (called pediatric environmental enteropathy here (PEE)) the red colored texts are tests dedicated to the aspects of the pathogenesis written in black

Chronic inflammation has been associated with decreased linear height and increased markers for inflammation, namely CRP have been found to be persistently higher in stunted children than in normal children (Prendergast et al., 2014). EED, caused by increased permeability of the GIT causing bacteria to cross the epithelium and initiating inflammation that makes it into the circulation, causing systemic inflammation and decreased growth factors, namely IGF-1(Prendergast et al., 2014). been linked to the pathogenesis of stunting. EED causes and is caused (thus it creates a vicious feedback loop) by dysbiosis of the GIT flora (Vonaesch et al., 2018). The condition causes a loop to arise in which more dysbiosis leads to more malnutrition and stunting which in turn leads to more dysbiosis (it has been shown that malnourishment leads to more severe and frequent infections (Costa et al., 2012)). It is noteworthy how similar the pathogenesis and morphology of EED to inflammatory bowel syndrome (IBD) is which means that the markers used to investigate and diagnose EED are similar to IBD (Johansson et al., 2013).

Clinical picture

Stunting is defined as the percentage of children whose height-for-age is below minus two standard deviations for moderate and minus three standard deviations for severe stunting from the median of the 2006 WHO Child Growth Standards (UNICEF, 2013). Similarly, children are considered severely stunted if their length/height is below -3 SDs from the WHO child growth standards median for the same age and sex.

Figure 38: Height-for-age difference in stunting

Stunted growth in children has the following public health impacts apart from the obvious impact of shorter stature of the person affected:

- Greater risk for illness and premature death (WHO, 2014)
- Delayed neurocognitive development and therefore poorer school performance and later on reduced productivity in the work force (WHO, 2014)
- Reduced cognitive capacity
- Future risk of obesity (De Sanctis et al., 2021)

- Women of shorter stature have a greater risk for complications during child birth due to their smaller pelvis, and are at risk of delivering a baby with low birth weight (WHO, 2014)

If your child is smaller than other children their age, they may have a growth problem. It's typically considered a medical issue if they're smaller than 95 percent of children their age, and their rate of growth is slow.

A growth delay may also be diagnosed in a child whose height is in the normal range, but whose rate of growth has slowed. Depending on the underlying cause of their growth delay, they may have other symptoms:

- If they have certain forms of dwarfism, the size of their arms or legs may be out of normal proportion to their torso.
- If they have low levels of the hormone thyroxine, they may have a loss of energy, constipation, dry skin, dry hair, and trouble staying warm.
- If they have low levels of growth hormone (GH), it can affect the growth of their face, causing them to look abnormally young.
- If their delayed growth is caused by stomach or bowel disease, they may have blood in their stool, diarrhea, constipation, vomiting, or nausea (McGurgan, 2018)

Stunting is highly associated with several long-term consequences, including higher rate of mortality and morbidity, deficient cognitive growth, school performance, learning capacity, work capacity and work productivity (WHO, 2015)

THE LIFETIME COSTS OF STUNTING
CHILD MORTALITY
STUNTED CHILDREN ARE
4x MORE LIKELY TO DIE
THAN CHILDREN WHO ARE NOT
IQ SCORES
STUNTING CAN REDUCE IQ BY AS MUCH AS 11 PTS
INCOME
ADULTS WHO ARE STUNTED EARN 22% LESS
ECONOMY
IN COUNTRIES LIKE ETHIOPIA
STUNTING CONTRIBUTES TO LOSSES IN GDP AS HIGH AS 16%

Figure 39: The lifetime costs of stunting

CNS growth and cognitive functions in stunted children

The developing brain is particularly vulnerable to nutrient insufficiency between 24 and 42 weeks of gestation because of the rapid course of several neurologic processes, including synapse formation and myelination (Fall CH et al., 2003) In healthy infants, there is well-

documented rapid brain growth in the first 2 years, this early period is also critical for long-term neurodevelopment (Bergvall N. et al, 2006; Gale CR et al., 2004)

.

Cognitive functions, receptive and expressive language, and socioemotional skills develop at different ages. Development in brain structure and function supporting acquisition of cognitive, language, and socioemotional skills is most rapid during early childhood, with continued development in later years for many skills. Undernutrition affects areas of the brain involved in cognition, memory, and locomotor skills. The brain has major energy demands in early childhood and most cerebral growth occurs in the first 2 years of life. However, the associations between poor linear growth and impaired neurodevelopment are not well understood (Prendergast AJ and Humphrey JH, 2014)

.

With chronic malnutrition, cognitive delays can occur throughout infancy, childhood, and adolescence, Measurable differences in receptive language by socioeconomic groups are apparent in preschool children ages three to five years; differences in cognitive ability have been observed even in the first two years (Walker SP et al., 2007).

In addition, the brain may be susceptible to poor nutrition during its ongoing remodelling and during recovering from various forms of damage. At approximately age 10, a child's brain represents 5–10% of body mass, consumes twice the glucose and 1.5 times the oxygen per gram of tissue compared with an adult's brain, and accounts for up to 50% of the total basal metabolic rate of the body (Bergvall N. et al., 2006; Gale CR et al., 2004; Fall CH et al., 2003). Thus, nutritional deprivation during adolescence may have an undesirable impact on brain functions (Galler JR et al., 2017).

linear growth defect

Chronic malnutrition in stunted children is associated with diminished levels of insulin-like growth factor 1 (IGF-1) synthesis. Even a transient 50% reduction in calorie or 33% reduction in protein availability can result in a reversible reduction in IGF-1 concentrations. The reduced levels of IGF-1 lead to a secondary. increase in growth

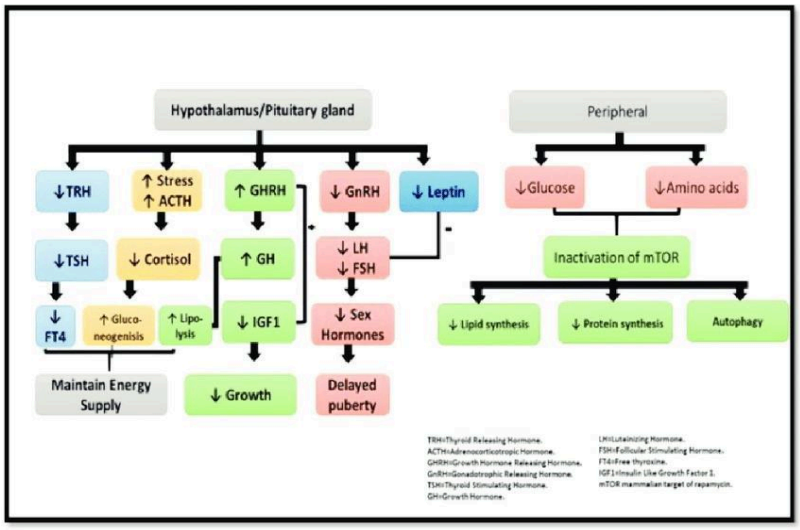


Figure 40: Mechanisms affecting linear growth during malnutrition

hormone (GH) through the negative feedback of low IGF-1 level on pituitary synthesis of GH. The end metabolic result is diversion of substrate away from growth toward metabolic homeostasis. The well-known metabolic effects of growth hormone, which are not IGF-1 dependent, would clearly be adaptive in the face of reduced substrate intake. These include increased lipolysis and mobilization of free fatty acids from adipose tissue stores and inhibition of glucose uptake by muscle tissue (Hawkes CP and Grimberg A., 2015; Soliman AT et al., 1986; Bartz S et al., 2014).

Investigation of Stunting

Anthropometric

1. Height for Age Z Score (WHO Procedure)

   Height-for-Age Z Score (HAZ) should be understood as the number of standard deviations of the actual height of a child from the median height of the children of his/her age as determined from the standard sample. This is prefixed by a positive sign (+) or a negative sign (-) depending on whether the child's actual height is more than the median height or less than the median weight. When the actual height of a child is exactly equal to the median, the resultant HAZ is zero (De Onis M et al., 2013)

   As per the agreed global standards, the following categories can be formed (Vonaesch P et al., 2017).

1	-1 < HAZ < 0	Normal
2	-2 < HAZ < -1	Marginally Stunted
3	-3 < HAZ < -2	Moderately Stunted
4	HAZ < -3	Severely Stunted

Table 7: Types of stunting according to standard deviations of anthropometric measurements

   WHO procedure normally involves using a calibrated wooden/plastic board with a headpiece and a movable foot piece which is used for measuring height or length of children (0–59 months of age). Its foot piece can also serve as a headpiece when measuring the standing height of children and compared with WHO standard growth formed (WHO, 2008).

2. Growth Length Mat

   Growth Length Mat also called descriptively as “Stunting Mat or Child Length Mat” is an innovative tool initially developed in Bolivia and adapted by a USAID funded project

(NOURISH) in Cambodia to support community and health workers to directly detect stunting and rapidly identify children who may need attention. mat seeks to address the need for special skills and processing needed to use the WHO procedure in determining child stunting .4 mat is 96 cm long and 50 cm wide It is made with a fexible and foldable material and relatively light to carry. The mat is colour coded to indicate the status of a child (normal or stunted) when placed on it depending on the sex and age and so measures child stunting directly (Save the Children n.d.).

Figure 41: Child Length Mat

The mat has 6 months age range that is 6, 12, and 18 months sections. For example, 6–11 months old children are grouped and children 12–17 months old also measured together as a group according to sex.

Therefore, stunted, but relatively older children within a group are more likely to touch the “normal line”, while normal but younger children of in a group are less likely to touch the “normal line”. Overall, the mat was very poor in detecting stunting in children over 12 months old. While the idea for a simple and easy tool to measure stunting is warranted, the mat will need substantial improvements in its design to improve its accuracy in detecting stunting in children before widespread adoption across populations (Bukari et al., 2022)

Figure 42: Child Length Mat used to screen for stunting in a baby girl

“The length mat is square with a yellow background and green stair for measuring the height of the child. Each green stair measures a different age of 6, 12, 18 and 24 months. There are two sides – one for a girl and one for a boy. When the heels reach the green stair, the height is normal. When the heels do not reach the green stair, the child is stunted.” (www.manoffgroup.com, n.d.)

Laboratory Studies

1. Blood Tests:

   Serum electrolytes, creatinine, bicarbonate, calcium, phosphate, alkaline phosphatase, albumin: A low bicarbonate level may indicate renal tubular acidosis, which can result in growth failure. Electrolyte levels and/or creatinine out of the reference range may indicate renal failure (Medscape, n.d.)

2. TSH-T4

   Thyroxine (T4) and thyroid-stimulating hormone (TSH): T4 and TSH levels are important to rule out hypothyroidism and to screen for panhypopituitarism as a cause for short stature and growth failure. As the serum total T4 assays measure both bound and unbound ("free") T4, freeT4 test is preferred for screening in most pediatric endocrine clinics.(Medscape, n.d.)

Stunting			
Governorate	Severe	Moderate	Stunting
Adh-Dhalea	11.9	30	41.9
Al-Baidha	15	27.1	42.2
Al-Jawf	18.1	28.8	46.8
Al-Mahweet	19.6	34.8	54.4
Amran	22.6	35.6	58.1
Dhamar	20.5	36.4	56.9
Hajjah	22.6	35.2	57.9
Hodeidah	17.3	31.1	48.5
Ibb	14.9	31	45.9
Raima	31	35.4	66.4
Sana'a	17.3	32	49.2
Sana'a City	13	28.2	41.2
Taiz	14.4	29.2	43.6
Sada'a	18.9	35.1	54.5
Ma'rib	11.5	29.4	40.9

Table 8: Prevalence of stunting in Yemeni governorates

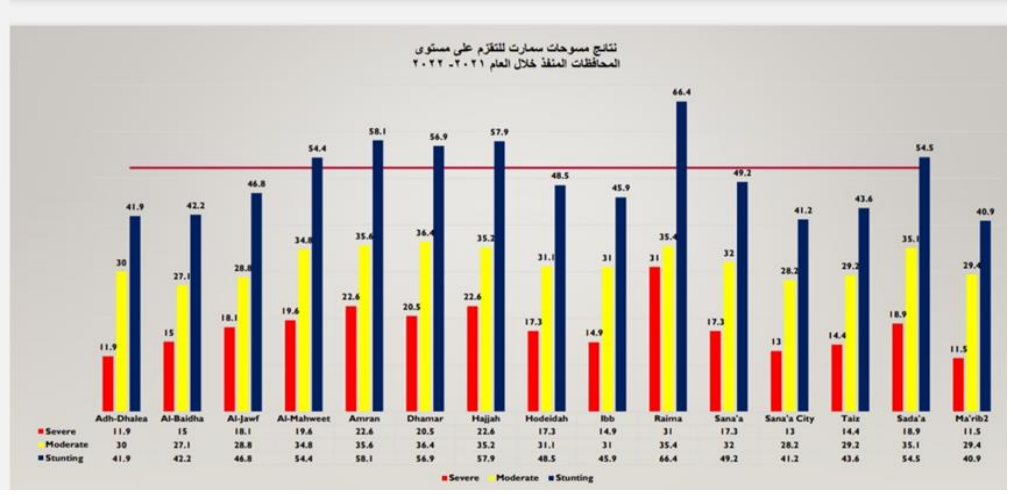


Figure 43: Results of SMART cross-sectional studies in Yemeni governorates (2021-2022) (MOF Yemen, n.d.)

Diagnosis of stunting

Calculated heights, weights and asked ages of children. They made the list of participants and provided the list to nutritionists. Nutritionists calculated height for age, obtained the stunted children from the lists and noted mild, moderate and severe stunted children.

Methods of diagnosis

1. Questionnaire design

   Questionnaire was designed by 3 Nutritionist to get the data about height, weight, age, BMI, anthropometric measurements, physical activities, demographic characteristics and diet to analyze the prevalence of stunting and effects of factors on stunting. After development, all questions in questionnaire were analyzed by 3 Pediatrician to validate the data asked in questionnaire.

2. Data collection

   Accurate measurement of height and weight using standardized techniques is a fundamental component of pediatric medical visits. Calculation of height velocity over time enables comparison with standardized growth charts to identify potential deviations from normal. Growth deviations may be expressed as SD from the normal population mean for children of comparable age and sex; children with heights >2 SD below the mean are generally classified as short stature (Vonaesch P. et al., 2017; WHO, 2015)

Management and Interventions for Stunting

A study reported that a combination of nutrition-specific and nutrition-sensitive interventions appears to be necessary for optimal reduction in stunting. Nutrition-specific interventions are those that address the immediate determinants of fetal and child nutrition, while nutrition-sensitive interventions address the underlying determinants of fetal and child nutrition and development (Ruel, Alderman and Maternal and Child Nutrition Study Group, 2013)

Nutrition-specific interventions	Nutrition-sensitive interventions
- Health and nutrition during adolescence, preconception, pregnancy and lactation - Maternal dietary or micronutrient supplementation - Promotion of optimum breastfeeding - Complementary feeding and responsive feeding practices and feeding stimulation - Dietary supplementation, food diversification and micronutrient supplementation or fortification for children - Treatment of SAM - Disease prevention and management - Nutrition in emergencies	- Agriculture and food security - Social safety nets - Early child development - Maternal mental health - Women's empowerment - Child protection - Schooling - Water, sanitation and hygiene (WASH) - Health and family planning services.

Table 9: A list of some nutrition-specific and nutrition-sensitive interventions for combating malnutrition

In a systematic review conducted by (Hossain et al., 2017), it was found that nutrition education and counselling, immunization, growth monitoring and promotion (GMP), water, sanitation and hygiene (WASH), and social safety net (SSN) programs were the most frequently included components in intervention packages designed to reduce stunting in low- and middle-income countries. In this study, Hossain and his colleagues concluded that combining nutrition-specific and nutrition-sensitive interventions, particularly those with strong health access and safety net components, resulted in the highest reduction of stunting rates. However, it is necessary to mention that there is not a single combination of interventions that universally, since the context within which these interventions are implemented appears to matter. For instance, in regions with high malarial burden, disease prevention and treatment has shown significant benefit in reducing stunting; therefore, programs that have worked in that region might not work in other regions that are not endemic with malaria or vice-versa. Following this, the study suggests that policy makers should design intervention packages that address the context of the region, by encouraging multi-sectorial collaboration between national and international agencies at the government level, and by encouraging community engagement and community-based service at the community level.

Butta and his colleagues have explored many nutrition-specific interventions and have used the Live Saved Tool (LiST) to model out the effects of 10 of the most effective intervention.

1. Periconceptional folic acid supplementation or fortification
2. Maternal balanced energy protein supplementation
3. Maternal calcium supplementation
4. Multiple micronutrient supplementation in pregnancy
5. Promotion of breastfeeding
6. Appropriate complementary feeding
7. Vitamin A in children 6-59 months of age
8. Preventive zinc supplementation in children 6-59 months of age
9. Management of SAM
10. Management of MAM

According to their analysis, management of SAM produced the highest effect on reduction of child mortality, followed by zinc supplementation and promotion of breastfeeding. The benefits of these interventions also carry out into the prevention of stunting. For instance, a daily dose of 10 mg of zinc over 24 weeks in children younger than 5 years could lead to a net gain of 0.37 cm in height (Yakoob et al., 2011). Exclusive breastfeeding was also shown to reduce the likelihood of stunting by 20% when compared to non-exclusive breastfeeding (Hadi et al., 2021).

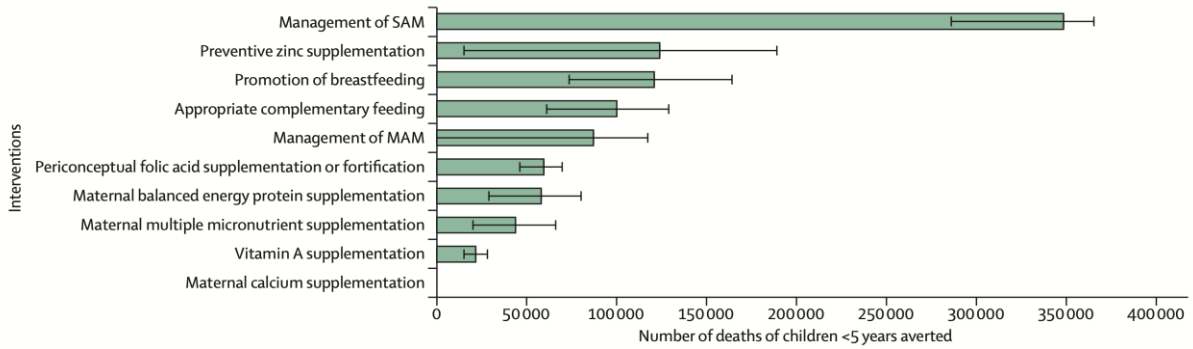


Figure 44: Most effective nutrition-specific interventions according to the LiST model on children <5 deaths

Several studies have shown a correlation between diary consumption and linear growth. (Duan et al., 2020) showed that diary intake had significant association with height-for-age Z-scores (HAZ) and a lower risk of. developing stunting. (Herber et al., 2020) has also shown that milk consumption reduced the probability of being stunted by 1.9 percentage points in a study conducted from survey data between 1990 to 2017 in low- and middle-income countries (LMIC). Since cow's milk protein is a key component of F-100 and ready-to-use therapeutic foods (RUFT) used to manage SAM (Michaelsen, 2013), it partially explains the 20.3%

reduction in stunting produced by the LiST model created by (Bhutta et al., 2013). However, a study conducted by (Binns and Myatt, 2018) has raised small concerns about the excessive use of RUTF in severely stunted children or children who are less than 65 cm tall and aged 6 months and older, as their study showed a tendency towards a higher triceps skin fold (TSF) thickness for age, raising the risk of becoming overweight or obese and later developing chronic non-communicable diseases.

Other than child nutrition, many factors take part in the prevention of stunting as mentioned in the table and figure previously. Care for women in child-bearing age and those who are pregnant is necessary for optimal child growth. For example, pre-pregnancy weight is considered a good predictor of delivering low-birth weight (LBW), and improving BMI of women 15-49 years of age corresponds with a reduction in the rate of LBW, thus also a reduction in the risk of stunting in children (Vir, 2016). In addition to improving the coverage of nutrition-specific interventions in women, the WHO also insists on intensifying the nutrition-sensitive measures for women. Examples of such measures include the prevention of early marriage, completion of secondary education, improving socioeconomic status and control over resources, reducing physical workload during pregnancy, and improving access to water, sanitation and cooking-fuel facilities (WHO 2018). Hygiene and clean water are also very crucial determinants for the development of stunting. Infectious diseases that are propagated by the lack of clean water are important determinants of childhood stunting (WHO 2018). An Indonesian study conducted by (Irianti et al., 2019) demonstrated that a reduction of the stunting burden in rural areas in Indonesia by 21.58% is possible by the provision of access to improved drinking water sources and better household solid waste management.

Chapter 4

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Underweight In Yemen

The greatest risk of undernutrition (underweight, stunting, wasting, and micronutrient deficiencies) occurs in the first 1000 days, from conception to 24mo of age, and this early damage to growth and development can have adverse consequences in later life on health, intellectual ability, school achievement, work productivity, and earnings. Governments and agencies are therefore advised to focus interventions on this critical window of opportunity.

Yemen is the poorest country in the Middle East and North Africa, and since March 2015 it has been facing a significant humanitarian and security crisis. The ongoing intensified war and disrupted social services have had a clear impact on the general health and nutrition status of the children and entire population. The food distribution mechanism in the country has been severely disturbed. Yemen is highly dependent on imported food, and the current armed conflict has blocked food transportation, which has caused a food crisis. The decrease in food availability has led to an increase in food costs, although the conflict has devastated purchasing power as a result of increased unemployment and loss of family incomes.

A complex combination of dietary practices and environmental, social and economic factors in countries of the Eastern Mediterranean Region has resulted in the persistence of what is described as the double-burden of malnutrition, where under-nutrition among young children and women of childbearing age co-exists with nutrition of excess, demonstrated by increasing rates of overweight, obesity and chronic diseases.

Yemen is one of the countries which are classified as country experiencing humanitarian crisis with high prevalence of severe child and maternal undernutrition and widespread micronutrient deficiencies. The overall proportion of underweight children under 5 years of age has, however increased In Yemen the situation has also deteriorated, with 46% of all under-5s being currently underweight compared with 30% in 1991–92. It is estimated that 53% of under-5s in Yemen are stunted, and 32% of babies are born with low birth weight. Nutritional status was elevated by the presence of underweight, stunting and wasting according to the WHO child growth standards.

The three anthropometric indicators such as (height for age, weight for height and weight for age) are used to examine the nutritional status of children aged less than 5 years in Yemen.

What does being underweight mean?

Underweight is defined as low weight-for-age. A child who is underweight may be stunted, wasted or both. Being underweight means you are below the healthy weight range — the weight that research has shown you need to be if your body is to work properly. Being outside this range, whether overweight or underweight, can seriously affect your health. Underweight people weigh too little and are too thin Opposite Overweigh, and their body weight is considered too low to be healthy.

- Measuring to knew underweight:

Body mass index (BMI) is calculated by dividing weight in kilograms by the square of height in meters. For children, BMI is age and gender specific. BMI for-

age can be used from birth to 20 yr and is a screening tool for thinness (less than −2 SD), overweight (between +1 SD and +2 SD), and obesity (greater than +2 SD). To diagnose obesity, additional measures of adiposity are desirable because a high BMI can result from high muscularity, and not only from excess subcutaneous fat.

The best measure of whether you are a healthy weight is the body mass index (BMI). This is calculated using your weight and your height. Formula of BMI: Person's weight in Kilograms (or Pound) divided by the square of height in meters In adults, a healthy weight range is a BMI of 18.5 to 24.9. If your BMI is under 185 you will be underweight.

Diagnostic-criteria-for-obesity-in-according-to-WHO-classification

What causes being underweight?

- In general People become underweight for many different reasons. Some may be born naturally small and their low BMI is due to their genes. Some may have a very high metabolism and find it hard to put on weight, even if they eat foods that have a lot of calories.
- Some people may not follow a healthy, balanced diet because they forget to eat or they cannot afford nutritious foods. Others may not be eating properly because they are sick, or their medicines make them feel nauseous. Some people who do a lot of physical activity burn up more calories than they can eat, leading to their being underweight.
- Some physical conditions can cause weight loss, leading to someone being underweight. These include: stomach problems, such as nausea, vomiting or diarrhea an infection, cancer, HIV or lung disease, diabetes, thyroid problems, Crohn's disease.
- Mental health problems can also cause someone to be underweight. These include: anxiety and stress eating disorders such as anorexia nervosa and bulimia dementia.
- People who have been ill, in hospital or who are elderly are more at risk of being underweight.

Major Factors that Cause Underweight

(1) failure to ingest sufficient calories, or starvation (e.g., cardiac failure, fluid restriction).

(2) increased nutrient losses (e.g., protein-losing enteropathy, chronic diarrhea).

(3) increased metabolic demands, as seen in extensive burn Injuries.

(4) altered nutrient absorption or utilization (e.g., cystic fibrosis, short bowel syndrome),More than one mechanism can exist simultaneously.

- Poor Food Intake in Children
- Insufficient Food Intake and Poor Diet in Adults and the Elderly
- Refugee and Migrant Status
- Orphans and Vulnerable Children

- Voluntary Consumption of Fad Diets
- Underweight Causes in the Elderly
- 7. Parasitic Infestation
- 8. Bacterial Food Infection and Food Poisoning
- 9. Food Allergies and Food Intolerances
- 10. Mineral and Vitamin Deficiencies

Consequences of being underweight

Inhibited, growth and development in form of stunting and wasting in children. Low lean body mass or low muscle mass, underweight individuals may have decreased muscle mass, which can lead to weakness and fatigue. Failure to thrive and developmental delays in children. Children who are underweight may experience, delay, growth, and development due to lack of proper nutrition, weakened immune systems expose a person to a large spectrum of infections and dangers rendering them more susceptible to infections than the average person. low body weight can increase the risk of developing osteoporosis a condition that makes bones more prone to fracture. anemia, vitamin deficiencies in normal and sickle cell patients, fertility issues such as amenorrhea failed conception and pregnancy complications, fertility problems due to hormonal imbalance is caused by inadequate nutrition resulting in poor pregnancy outcomes,, hormonal dysregulation, menstruation problems, hair loss, and hair thinning, poor ingestion, digestion, absorption, and assimilation of food that results in frailty. chronic, and general fatigue heart rhythm problems, low energy weakness and dizziness hypothermia hypoglycemia burns that take long to heal, poor wound healing and pressure ulcers, psychological issues such as poor self image lack of self confidence self-esteem issues and stress bad mood and unexplained anger aggression due to hunger poor self control, force her sleep and stres increased mortality.

Category	BMI value
Underweight	≤ 18.5
Normal Weight	18.5- 24.9
Overweight	25-29.9
Obesity Type 1	30-34.9
Obesity Type 2	≥ 35

Table 10: BMI scores for different bodyweight categories.

Epidemiology of underweight:

according to the world health organization, (WHO) Yemen has one of the highest rates of underweight children in the world. In 2018 it was estimated a 2.9 million children under the age of five were underweight in Yemen, which is approximately 46% of all the children in this age group. According to the world food program WFP more than 20 million people in Yemen are food insecure and over 10 million are acutely food insecure this situation has led to a high prevalence of malnutrition among children and adults. Underweight is a common form of malnutrition in Yemen. According to the United Nations, children's fund UNICEF around 2.3 million children under the age of five are actually malnourished, including 400,000 who suffers from severe acute malnutrition SAM. SAM is a life-threatening condition that requires urgent treatment

Pathophysiology

Inadequate energy intake leads to various physiologic adaptations, including growth restriction, loss of fat, muscle, and visceral mass, reduced basal metabolic rate, and reduced total energy expenditure. The biochemical changes in acute malnutrition involve metabolic, hormonal, and glucoregulatory mechanisms. The main hormones affected are the thyroid hormones, insulin, and the growth hormone (GH). Changes include reduced levels of tri-iodothyroxine (T3), insulin, insulin-like growth factor-1 (IGF-1) and raised levels of GH and cortisol. Glucose levels are often initially low, with depletion of glycogen stores. In the early phase there is rapid gluconeogenesis with resultant loss of skeletal muscle caused by use of amino acids, pyruvate and lactate. Later there is the protein conservation phase, with fat mobilization leading to lipolysis and ketogenesis. Major electrolyte changes including sodium retention and intracellular potassium depletion can be explained by decreased activity of the glycoside-sensitive energy-dependent sodium pump to increased permeability of cell membranes in kwashiorkor.

Organ systems are variably impaired in acute malnutrition. Cellular immunity is affected because of atrophy of the thymus, lymph nodes, and tonsils. There are reduced cluster of differentiation (CD) 4 with normal CD8-T lymphocytes, loss of delayed hypersensitivity, impaired phagocytosis, and reduced secretory immunoglobulin A. Consequently, the susceptibility to invasive infections (urinary, gastrointestinal infections, septicemia, etc.) is increased.

Villous atrophy with resultant loss of disaccharidases, crypt hypoplasia, and altered intestinal permeability results in malabsorption. Other common aspects are bacterial overgrowth and pancreatic atrophy resulting in fat malabsorption; fatty infiltration of the liver is also common. Drug metabolism may be decreased due to decreased plasma albumin and decreased fractions of the glycoprotein responsible for binding drugs.

Cardiac myofibrils are thinned with impaired contractility. Cardiac output is reduced proportionate to weight loss. Bradycardia and hypotension are also common in severe cases. The combination of bradycardia, impaired cardiac contractility, and electrolyte imbalances predisposes to arrhythmias. Reduced thoracic muscle mass, decreased metabolic rate, and

electrolyte imbalances (hypokalemia and hypophosphatemia) may result in decreased minute ventilation and impaired ventilatory response to hypoxia.

Acute malnutrition has been recognized as causing reduction in the numbers of neurons, synapses, dendritic arborizations, and myelinations, all of which resulting in decreased brain size. The cerebral cortex is thinned and brain growth slowed. Delays in global function, motor function, and memory have been associated with malnutrition. The effects on the developing brain may be irreversible after the age of 3–4 years.

Clinical picture (symptoms and signs) of underweight

1. Severe weight loss .
2. Severe facial boney prominence :
3. immune system: reduced immunity due to atrophy of the thymus , lymph nodes ,tonsils
4. Cardiovascular system : reduced cardiovascular output proportionate to weight loss bradycardia ,arrhythmia hypotension
5. Respiratory system : impaired breathing response to hypoxia
6. Nervous system : reduction in number of neurons and synapses ,slowed brain growth ,delays in global brain function motor and function memory
7. Face : simia faces (marasmus)
8. Osteoporosis : In being underweight increases a woman's risk of osteoporosis, which is where the bones are brittle and more prone to breaking.
9. Skin: wrinkled, dry, follicular, thinning hyperkeratosis, patchy, hyper and hypo-pigmented ,erosion ,poor wound healthy.
10. Hair: dull, hair loss, sparse ,brittle hair ,hypopigmentation ,flag sign (alternatig bands otlight and normal color) broomstick eyelashes , alopecia .
11. Getting sick frequently: if a person does not get enough energy from their diet to maintain a healthy body weight, they may also not be getting enough nutrients to fight off .
12. Infections: As a result, a person may get sick more frequently, and common illnesses, such as a cold, can last longer than they usually would.
13. Lower body temperature:
14. Muscles loss
15. Feeling tired all the time : Calories are a measurement of the energy a particular food can give a person. Not getting enough calories to maintain a healthy weight can make a person feel fatigued.
16. Anemia : A person who is underweight is more likely to have low blood counts, known as anemia, which causes dizziness, headaches, and fatigue.
17. Irregular periods: Women who are underweight may not have regular periods, they may find menstruation stops, or an adolescent's first period may be delayed or absent. Irregular or absent menstruation can cause infertility.

18. Premature births: According to a study published in An International Journal of Obstetrics & Gynecology Trusted Source, a woman who is pregnant and underweight is at a higher risk for pre-term labor, which means having a baby before 37 weeks.
19. Slow or impaired growth: Young people need nutrients to grow and develop healthy bones. Being underweight and not getting enough calories could mean a person may not develop as expected. Doctors call this a 'failure to thrive.'

Sever weight loss and wasting

Loss of musculature

Prominence of facial bone

manifestations of malnutrition in hair

Apathy and lack of emotion

Simia faces

Figure 45: Signs and symptoms of being

Investigation of underweight

- Thorough laboratory testing should be conducted to evaluate for seveity and any complication
    1) CBC
    2) Electrolyte panel .
    3) Inflammatory marker
    4) Organ function tests
- Typical findings;

Anemia, electrolyte abnormalities such as, hypokalemia, hyponatremia, hypophosphatemia, hypocalcemia, hypomagnesemia; decreased lymphocyte count, increased BUN and creatinine, increased CRP if associated with an inflammatory condition, tentative presence of ova and parasites in stool cultures.

Underweight is diagnosed by performing the following nutritional assessment

A. Anthropometry:

- Anthropometry provides a valuable assessment of nutritional status in children and adults Common anthropometric measurements include weight, height, MUAC, head circumference, and skin-fold thickness, body circumferences to assess for adiposity (waist, hip, and limbs), weight-for-height z-score (WHZ) for children and BMI for adult. Children whose weight for age measures are below minus two standard deviations (−2SD) from the median of the reference population are considered underweight.
- A child is underweight if they’re in the bottom 5th percentile for weight compared to their height.
- An adult person with a BMI of less than 18.5 is underweight.

2. Biochemical (laboratory)

Serum laboratory tests like electrolytes, total protein, prealbumin, and albumin tests can heldetermine which nutrients are inadequate.

3. Assess for physical signs of underweight.

4. Assess the patient’s nutritional history.

Management of underweight

A. prevention.
    1. Providing micronutrient intervention such as minerals and vitamines.
    2. Regular check of growth.
    3. Oral rehydration in high diarrhea regions.
    4. Fortifying commonly eaten foods.

B. Treatment.

A. Dietetic treatment Dietary foods should be contain:

1. Proteins rich foods.
   - High intake of protein to build up muscle tissue
   - Daily protein intake 1.5-2g/kg
2. Carbohydrates
   - High levels of carbohydrates should be recommended to supply energy and to do protein sparing effect.
3. Energy
   - Daily energy intake 500kcal per day.
4. Fats.

B. Only in moderation to partly meet energy.

- Supportive treatment

1. multivitamins especially:
   - B-complex/vitamin A and vitamin D
2. Minerals supplement especially:
   - Magnesium
   - phosphorus
   - calcium
   - iron
   - zink and copper.

C. Intervention of underweight

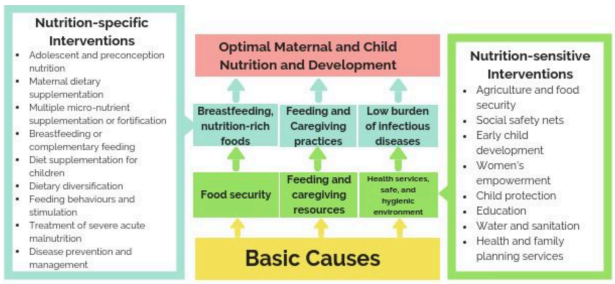

Figure 46: a diagram showing kinds of intervention in treating underweight individuals.

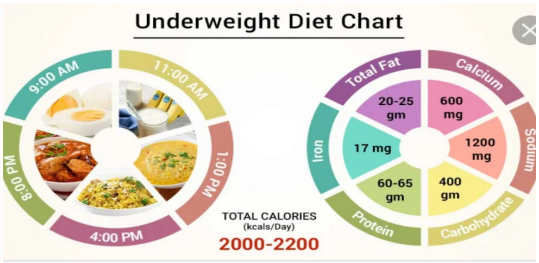

Figure 47: Diet chart showing some foods and their caloric value as a scheme for treating underweight.

Chapter 5

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WASTING (acute malnutrition)

Definition

Wasting' is one of the key indicators used to assess the prevalence of childhood malnutrition. A child is defined as 'wasted' if their weight is too low for their height. (Ritchie,H. , 2022)

Wasting refers to children who are too thin for their height due to recent weight loss from lack of nutritional intake and illness. Wasting, and especially severe acute malnutrition, in young children is a medical emergency with high risk of mortality and negative consequences for human development. Child wasting remains a problem in low- and middle-income countries (Karlsson, 2022)

Wasting is often referred to as acute malnutrition. It is a sign that a child has experienced short periods of undernutrition, resulting in significant wastage of muscle and fat tissue. This means their weight is very low for their height (Ritchie,H., 2022), and sometime Wasting defined as "Moderate and severe acute malnutrition - below minus two standard deviations from median weight for height of reference population" (UNICEF, WHO, & Group, W. B., 2016). Moderate and severe wasted children have an increased mortality rate. However, the treatment and cure are conceivable (De Onis, 2012).

Acute malnutrition defined as a nutritional deficiency resulting from either inadequate protein or energy intake .

Causes and associated factor of wasting

Wasting can be caused by acute but severe periods of food shortage, or disease, or both. This is often caused by periods of severe food insecurity in a population – such as during famine, or seasons of very poor crop harvest. It can also be the result of bouts of infection. (Ritchie,H., 2022)

Some of the common causes of wasting include:

- Inadequate intake of food: Not consuming enough food, particularly high-quality protein and essential nutrients often leads to wasting.
- Digestive problems: People with digestive issues such as diarrhea, vomiting, and malabsorption may not be able to take in enough nutrients from food.
- Chronic infections: Chronic infections like tuberculosis, HIV/AIDS, and other diseases reduce the body's ability to absorb nutrients from food , or where a child's energy requirements may be higher and their ability to absorb and retain nutrients is limited

- Metabolic disorders: Certain metabolic disorders like hyperthyroidism, which increases the body's metabolism, can cause wasting.
- Cancer: Cancer can cause wasting due to the body's increased need for nutrients to combat the disease and the side effects of cancer treatment.
- Eating disorders: Eating disorders like anorexia nervosa and bulimia nervosa can lead to wasting.
- Poverty: People living in poverty may not have access to enough food, clean water, and basic healthcare which can lead to wasting.

Classification of wasting (acute malnutrition)

According to causes :

1. Primary acute malnutrition : in children is the result of inadequate food supply caused by socioeconomic, political, and environmental factors, and it is most commonly seen in low- and middle-income countries (Grover, Z., 2009)
2. Secondary acute malnutrition : is usually due to abnormal nutrient loss, increased energy expenditure, or decreased food intake, frequently in the context of underlying, mostly chronic, diseases like cystic fibrosis, chronic renal failure, chronic liver diseases, childhood malignancies, congenital heart disease, and neuromuscular diseases (Grover, Z., 2009).

According to severity:

1. Moderate Acute Malnutrition (MAM) : is defined as a moderate degree of malnutrition, with a weight-for-height between -2 and -3 z-scores of the median WHO growth standards , is less severe and has a lower risk of complications (Koletzko, B, 2015)
2. Severe Acute Malnutrition (SAM) : is defined as having an extremely low weight for height (below -3 z-scores of the median WHO growth standards) , is usually associated with higher risks of severe medical complications, such as infection, organ failure, and death. (Koletzko, B, 2015)

Epidemiology

- Wasting reflects infections and poor nutrition and affects almost 50 million children at any given time. Wasting comes with immediate risk of mortality and increased risks for long-term negative consequences for development. Children under two are particularly sensitive to undernutrition and infections. We estimated the age patterning in wasting prevalence. since

the wasting prevalence was observed to be greater among children 0–2 years old than 2–4 years (Karlsson, 2022)

- Timor-Leste, India, Niger, and Yemen had the highest wasting rates (> 16%). While Paraguay, Peru, Guatemala, Colombia, and Bolivia had the lowest wasting rates in our sample countries (< 1%) (Rafi, 2022)
- Around 9% of the sample countries had intra-country lowest and highest wasting rate differences of 20% percentage points or more (Fig. 5). The highest intra-country wasting differences were found in Kenya (22%), India (23%), Timor-Leste (25%), and Niger (27%). The lowest intra-country wasting rates differences were found in Trinidad and Tobago (0.0%), Rwanda (0.6%), Paraguay (0.8%) Swaziland (1.0%). Over 800 thousand under-5 deaths (or 12–13% of all under-5 deaths) were attributed to wasting in 2011. (Rafi, 2022)
- In 2015, it was globally estimated that 50 million children were wasted. Approximately, 8 lac children died due to wasting. Globally, in 2018, 49 million (7.3%) of children having age of <05 years were wasted. According to national nutritional survey 2018, and 17.7% children were wasted (UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates, 2019).
- In one study among 3101 hospitalized children in nine countries in sub-Saharan Africa in 2019; it was found that 24.6% of the hospitalized children had moderate wasting, and 39·3% had severe wasting with death rate of 11·3% (Abdoulaye Baniré Diallo et al., 2022)
- The prevalence of acute and severe malnutrition among children under 5 is above the World Health Assembly target of reducing and maintaining prevalence at under 5% by 2025 .

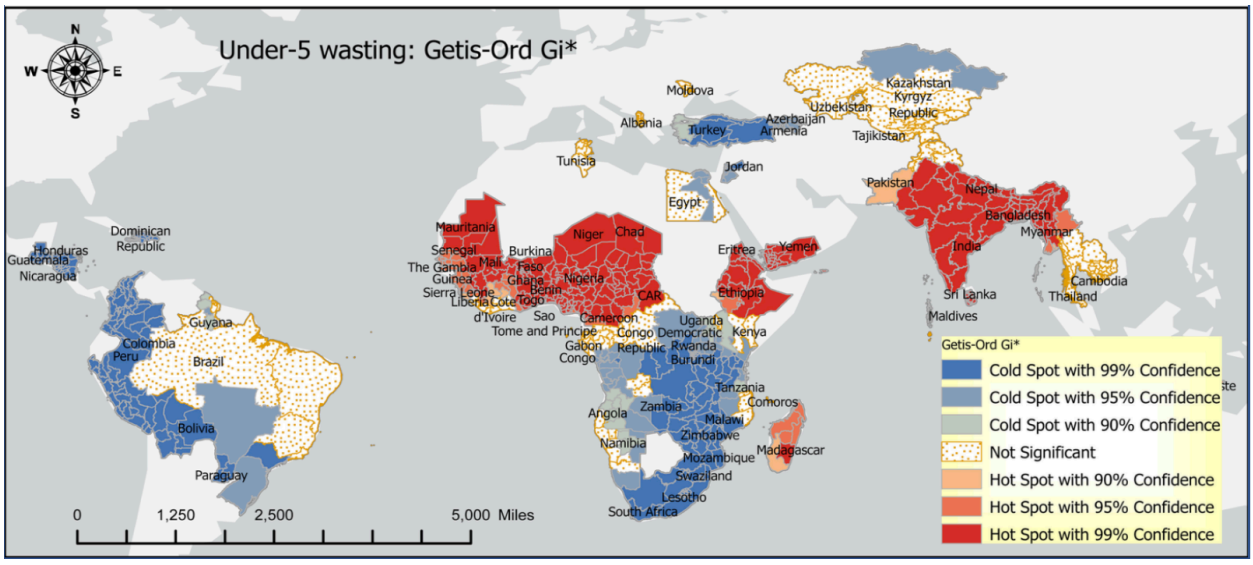


Figure 48: A partial map of the world describing the prevalence and severity of wasting.

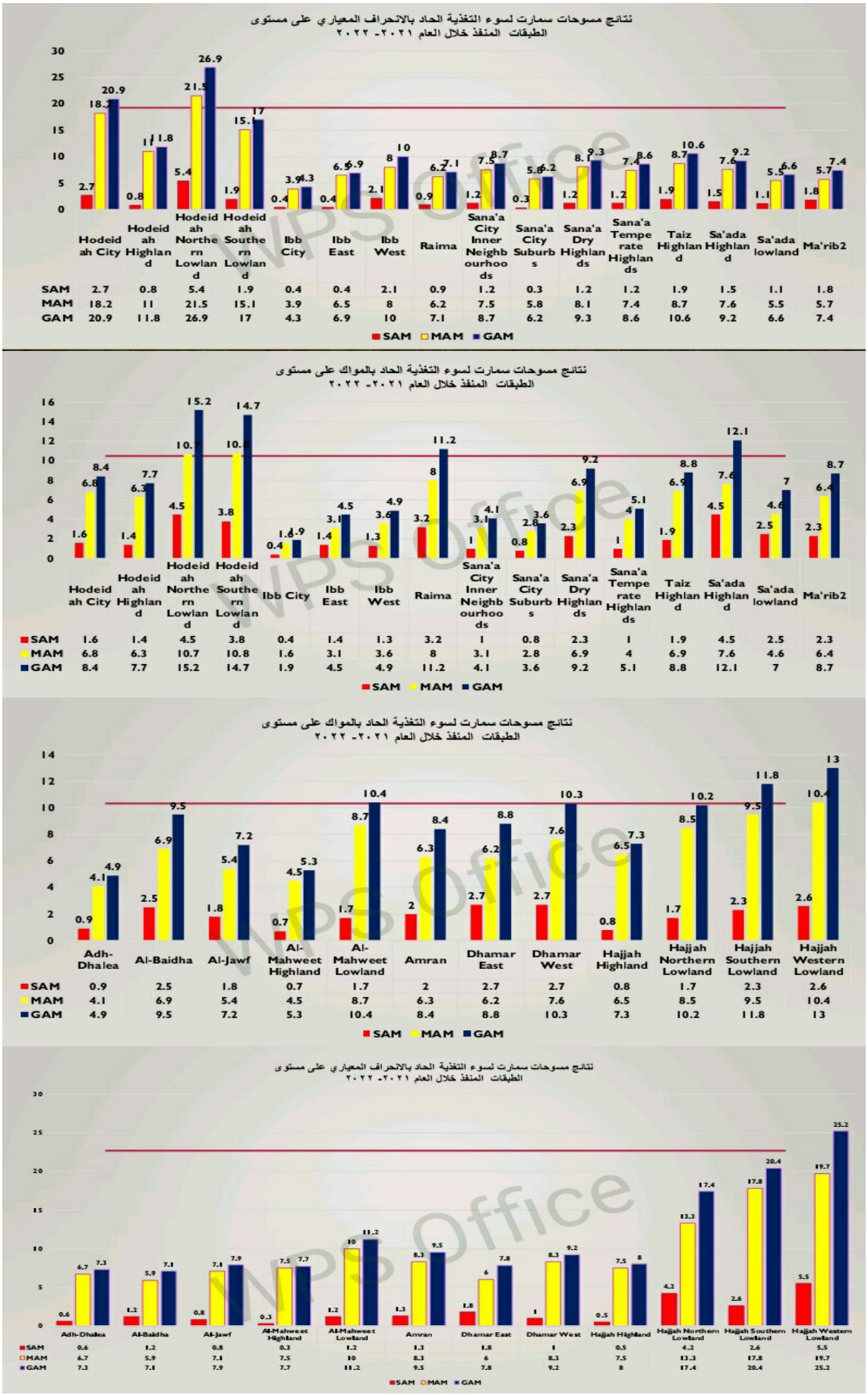
Epidemiology of wasting in Yemen

- In a population, the prevalence of wasting is defined as the share of child under five years old that fall two standard deviations below the expected weight for their height. (Ritchie,H., 2022)
- about 370 000 of Yemen children are suffering from severe malnutrition. Additionally, one million children younger than five years old are at risk of acute malnutrition (Eshaq, 2017).
- Yemen remain among the highest in the world, with 2.3 million children under five years requiring treatment for acute malnutrition (World Food Programme, 2022).
- GAM for both Ibb and Sana'a governorates was 13.3% (WHZ). This high prevalence of acute malnutrition is classified as a critical phase, although it does not exceed the emergency threshold 15% (Khursheed N, 2012). The national rate of GAM for Yemen was 16% in the last demographic health survey (DHS) in 2013 . However, the Nutrition Cluster report (SMART) in April 2017 showed that the GAM rates in both governorates were classified as poor (between 5% to 9.99%) (World Health Organization, 2013). The difference in GAM rates between this survey and SMART 2017 could be due to seasonal differences that made comparisons invalid or the seasonal impact of nutrition interventions in both governorates. (Kapur, 2005)
- The analysis of acute malnutrition in 2018 for the Integrated Phase Classification of Food Security in Yemen shows that high malnutrition rates are present in Abyan governorate (23%) and Lahj governorate (21%). This analysis was community based addressed all children and mostly due to problems related to food intake. The role of diseases was not yet addressed in Yemen. (Al-waleedi, 2022)
- Recent study in 2022 reported that more than 2.3 million children under the age of five in Yemen suffer from acute malnutrition. Approximately 450,000 are expected to suffer from severe acute malnutrition and may die if they do not receive urgent treatment.

Wasting by MUAC			
Zoen	SAM	MAM	GAM
Adh-Dhalea	0.9	4.1	4.9
Al-Baidha	2.5	6.9	9.5
Al-Jawf	1.8	5.4	7.2
Al-Mahweet Highland	0.7	4.5	5.3
Al-Mahweet Lowland	1.7	8.7	10.4
Amran	2	6.3	8.4
Dhamar East	2.7	6.2	8.8
Dhamar West	2.7	7.6	10.3
Hajjah Highland	0.8	6.5	7.3
Hajjah Northern Lowland	1.7	8.5	10.2
Hajjah Southern Lowland	2.3	9.5	11.8
Hajjah Western Lowland	2.6	10.4	13
Hodeidah City	1.6	6.8	8.4
Hodeidah Highland	1.4	6.3	7.7
Hodeidah Northern Lowland	4.5	10.7	15.2
Hodeidah Southern Lowland	3.8	10.8	14.7

Wasting by weight for height z-score			
Zoen	SAM	MAM	GAM
Adh-Dhalea	0.6	6.7	7.3
Al-Baidha	1.2	5.9	7.1
Al-Jawf	0.8	7.1	7.9
Al-Mahweet Highland	0.3	7.5	7.7
Al-Mahweet Lowland	1.2	10	11.2
Amran	1.3	8.3	9.5
Dhamar East	1.8	6	7.8
Dhamar West	1	8.3	9.2
Hajjah Highland	0.5	7.5	8
Hajjah Northern Lowland	4.2	13.3	17.4
Hajjah Southern Lowland	2.6	17.8	20.4
Hajjah Western Lowland	5.5	19.7	25.2
Hodeidah City	2.7	18.2	20.9
Hodeidah Highland	0.8	11	11.8
Hodeidah Northern Lowland	5.4	21.5	26.9
Hodeidah Southern Lowland	1.9	15.1	17

Table 11: Tables for wasting by MUAC and weight for height in z-score in various Yemeni districts.


نتائج مسوحات سمارت لسوء التغذية الحاد بالانحراف المعياري على مستوى
الطبقات المنفذ خلال العام ٢٠٢١- ٢٠٢٢
Hodeidah City
Hodeidah Highland
Hodeidah Northern Lowland
Hodeidah Southern Lowland
Ibb City
Ibb East
Ibb West
Raima
Sana'a City Inner Neighbourhoods
Sana'a City Suburbs
Sana'a Dry Highlands
Sana'a Temperate Highlands
Taiz Highland
Sa'ada Highland
Sa'ada lowland
Ma'rib2
SAM 2.7 0.8 5.4 1.9 0.4 0.4 2.1 0.9 1.2 0.3 1.2 1.2 1.9 1.5 1.1 1.8
MAM 18.2 11 21.5 15.1 3.9 6.5 8 6.2 7.5 5.8 8.1 7.4 8.7 7.6 5.5 5.7
GAM 20.9 11.8 26.9 17 4.3 6.9 10 7.1 8.7 6.2 9.3 8.6 10.6 9.2 6.6 7.4
SAM MAM GAM
نتائج مسوحات سمارت لسوء التغذية الحاد بالمواك على مستوى
الطبقات المنفذ خلال العام ٢٠٢١- ٢٠٢٢
Hodeidah City
Hodeidah Highland
Hodeidah Northern Lowland
Hodeidah Southern Lowland
Ibb City
Ibb East
Ibb West
Raima
Sana'a City Inner Neighbourhoods
Sana'a City Suburbs
Sana'a Dry Highlands
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Taiz Highland
Sa'ada Highland
Sa'ada lowland
Ma'rib2
SAM 1.6 1.4 4.5 3.8 0.4 1.4 1.3 3.2 1 0.8 2.3 1 1.9 4.5 2.5 2.3
MAM 6.8 6.3 10.7 10.8 1.6 3.1 3.6 8 3.1 2.8 6.9 4 6.9 7.6 4.6 6.4
GAM 8.4 7.7 15.2 14.7 1.9 4.5 4.9 11.2 4.1 3.6 9.2 5.1 8.8 12.1 7 8.7
SAM MAM GAM
نتائج مسوحات سمارت لسوء التغذية الحاد بالمواك على مستوى
الطبقات المنفذ خلال العام ٢٠٢١- ٢٠٢٢
Adh-Dhalea
Al-Baidha
Al-Jawf
Al-Mahweet Highland
Al-Mahweet Lowland
Amran
Dhamar East
Dhamar West
Hajjah Highland
Hajjah Northern Lowland
Hajjah Southern Lowland
Hajjah Western Lowland
SAM 0.9 2.5 1.8 0.7 1.7 2 2.7 2.7 0.8 1.7 2.3 2.6
MAM 4.1 6.9 5.4 4.5 8.7 6.3 6.2 7.6 6.5 8.5 9.5 10.4
GAM 4.9 9.5 7.2 5.3 10.4 8.4 8.8 10.3 7.3 10.2 11.8 13
SAM MAM GAM
نتائج مسوحات سمارت لسوء التغذية الحاد بالانحراف المعياري على مستوى
الطبقات المنفذ خلال العام ٢٠٢١- ٢٠٢٢
Adh-Dhalea
Al-Baidha
Al-Jawf
Al-Mahweet Highland
Al-Mahweet Lowland
Amran
Dhamar East
Dhamar West
Hajjah Highland
Hajjah Northern Lowland
Hajjah Southern Lowland
Hajjah Western Lowland
SAM 0.6 1.2 0.8 0.3 1.2 1.3 1.8 1 0.5 4.2 2.6 5.5
MAM 6.7 5.9 7.1 7.5 10 8.3 6 8.3 7.5 13.3 17.8 19.7
GAM 7.3 7.1 7.9 7.7 11.2 9.5 7.8 9.2 8 17.4 20.4 25.2
SAM MAM GAM
WPS Office

Figure 49: Charts showing the prevalence and of malnutrition in Yemen in years 2021-2022. The 4 charts use different methods of measurement.

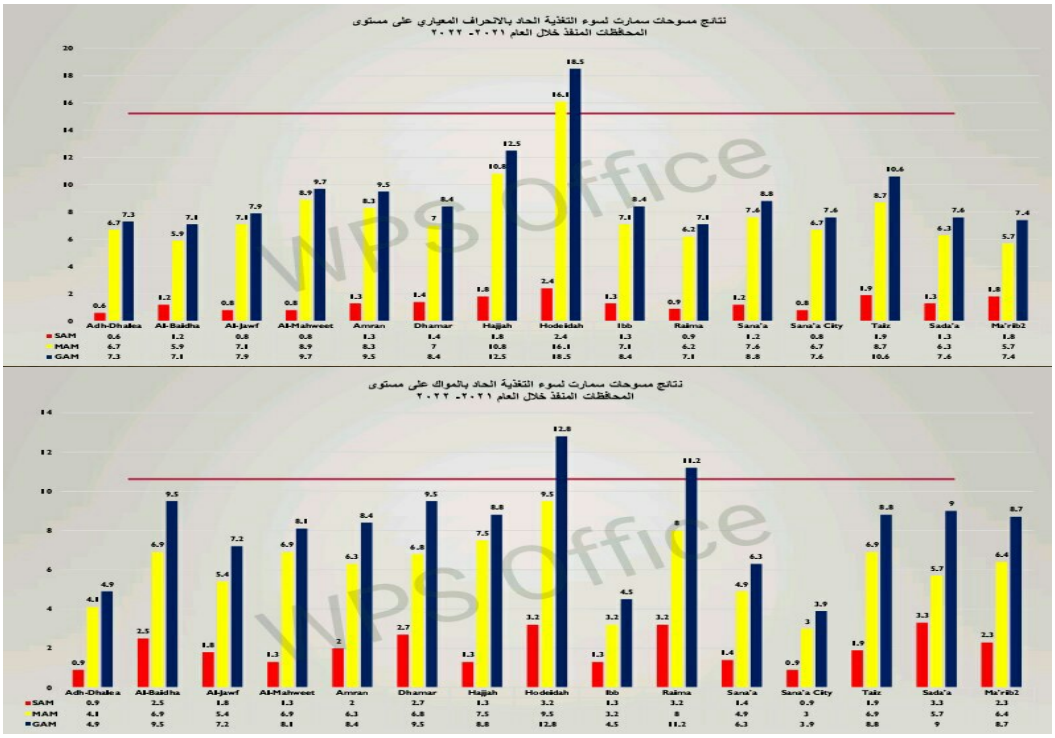


Figure 50: The results of the SMART study for acute malnutrition using different metrics.

Wasting by weight for height z-score			
Governorate	SAM	MAM	GAM
Adh-Dhalea	0.6	6.7	7.3
Al-Baidha	1.2	5.9	7.1
Al-Jawf	0.8	7.1	7.9
Al-Mahweet	0.8	8.9	9.7
Amran	1.3	8.3	9.5
Dhamar	1.4	7	8.4
Hajjah	1.8	10.8	12.5
Hodeidah	2.4	16.1	18.5
Ibb	1.3	7.1	8.4
Raima	0.9	6.2	7.1
Sana'a	1.2	7.6	8.8
Sana'a City	0.8	6.7	7.6
Taiz	1.9	8.7	10.6
Sada'a	1.3	6.3	7.6
Ma'rib2	1.8	5.7	7.4

Wasting by MUAC			
Governorate	SAM	MAM	GAM
Adh-Dhalea	0.9	4.1	4.9
Al-Baidha	2.5	6.9	9.5
Al-Jawf	1.8	5.4	7.2
Al-Mahweet	1.3	6.9	8.1
Amran	2	6.3	8.4
Dhamar	2.7	6.8	9.5
Hajjah	1.3	7.5	8.8
Hodeidah	3.2	9.5	12.8
Ibb	1.3	3.2	4.5
Raima	3.2	8	11.2
Sana'a	1.4	4.9	6.3
Sana'a City	0.9	3	3.9
Taiz	1.9	6.9	8.8
Sada'a	3.3	5.7	9
Ma'rib2	1.8	5.7	7.4

Table 12: Tables for wasting by MUAC and weight for height in z-score in various Yemeni governorates.

Pathophysiology of wasting

- The biochemical changes in acute malnutrition involve metabolic, hormonal, and glucoregulatory mechanisms. The main hormones affected are the thyroid hormones, insulin, and the growth hormone (GH). Changes include reduced levels of tri-iodothyroxine (T3), insulin, insulin-like growth factor-1 (IGF-1) and raised levels of GH and cortisol (Dureab, 2016).
- Glucose levels are often initially low, with depletion of glycogen stores. In the early phase there is rapid gluconeogenesis with resultant loss of skeletal muscle caused by use of amino acids, pyruvate and lactate. Later there is the protein conservation phase, with fat mobilization leading to lipolysis and ketogenesis.
- Major electrolyte changes including sodium retention and intracellular potassium depletion can be explained by decreased activity of the glycoside-sensitive energy-dependent sodium pump to increased permeability of cell membranes in kwashiorkor (Dureab, 2016).
- Organ systems are variably impaired in acute malnutrition . Cellular immunity is affected because of atrophy of the thymus, lymph nodes, and tonsils. There are reduced cluster of differentiation (CD) 4 with normal CD8-T lymphocytes, loss of delayed hypersensitivity, impaired phagocytosis, and reduced secretory immunoglobulin A. Consequently, the susceptibility to invasive infections (urinary, gastrointestinal infections, septicemia, etc.) is increased (Dureab, 2016).

Clinical Syndromes :

Acute malnutrition pertains to a group of linked disorders that includes kwashiorkor, marasmus, and intermediate states of marasmic kwashiorkor. They are distinguished based on clinical findings, with the primary distinction between kwashiorkor and marasmus being the presence of edema in kwashiorkor (Dureab, 2016).

- **Marasmus**
    1. The term “marasmus” is inferred from the Greek word “marasmus”, correlating to wasting or withering. (Dipasquale, 202)

2. Marasmus is the most frequent syndrome of acute malnutrition. It is due to inadequate energy intake over a period of months to years. It results from the body's physiologic adaptive response to starvation in response to severe deprivation of energy and all nutrients. (Dipasquale, 2022)

3. Is characterized by wasting of body tissues, particularly muscles and subcutaneous fat, and is usually a result of severe restrictions in energy intake. (Dipasquale, 2022)

4. Children younger than five years are the most commonly involved because of their increased caloric requirements and increased susceptibility to infections (Dipasquale, 2022).

5. These children appear emaciated, weak and lethargic, and have associated bradycardia, hypotension, and hypothermia. Their skin is xerotic, wrinkled, and loose because of the loss of subcutaneous fat, but is not characterized by any specific dermatosis (De Onis, 2012). Muscle wasting often starts in the axilla and groin (grade I), then thighs and buttocks (grade II), followed by chest and abdomen (grade III), and finally the facial muscles (grade IV), which are metabolically less active. In severe cases, the loss of buccal fat pads gives the children an aged facial aspect. Severely affected children are often apathetic but become irritable and difficult to console (Dipasquale, 2022).

- **Kwashiorkor**

1. The term "kwashiorkor" derives from the Kwa language of Ghana and its meaning is equivalent to "the sickness of the weaning" (Dureab, F, 2019). Cicely D. Williams first used the term in 1933. (Dipasquale, 2022)

2. Kwashiorkor is thought to be the result of inadequate protein but reasonably normal caloric intake. (Dipasquale, 2022)

3. It was first reported in children with maize diets (these children have been called "sugar babies", as their diet is typically low in protein but high in carbohydrate) (Dipasquale, 2022)

4. Kwashiorkor is frequent in developing countries and mainly involves older infants and young children. It mostly occurs in areas of famine or with limited food supply, and particularly in those countries where the diet consists mainly of corn, rice and beans (Khursheed, 2012). Kwashiorkor represents a maladaptive response to starvation. (Dipasquale, 2022)

5. Edema is the distinguishing characteristic of kwashiorkor, which does not exist in marasmus, and usually results from a combination of low serum albumin, increased cortisol, and inability to activate the antidiuretic hormone. It usually starts as pedal edema (grade I), then facial edema (grade II), paraspinal and chest edema (grade III) up to the association with ascitis (grade IV). (Dipasquale, 2022)

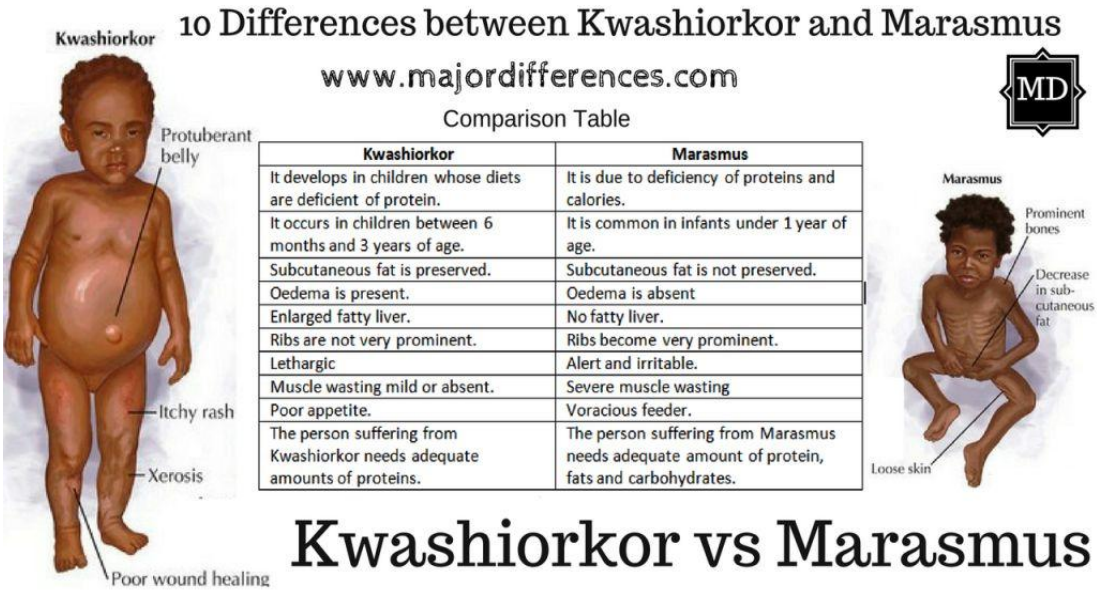
6. Besides edema, clinical features are almost normal weight for age, dermatoses, hypopigmented hair, distended abdomen, and hepatomegaly. Hair is usually dry, sparse, brittle, and depigmented, appearing reddish yellow. Cutaneous manifestations are characteristic and progress over days from dry atrophic skin with confluent areas of hyperkeratosis and hyperpigmentation. (Dipasquale, 2022)

7. Various skin changes in children with kwashiorkor include shiny, varnished-looking skin (64%), dark erythematous pigmented macules (48%), xerotic crazy paving skin (28%), residual hypopigmentation (18%), and hyperpigmentation and erythema (11%) (Dipasquale, 2022)

- **Marasmic Kwashiorkor**

1. Marasmic kwashiorkor is represented by mixed features of both marasmus and kwashiorkor. (Dipasquale, 2022)

2. Characteristically, children with marasmic kwashiorkor have concurrent gross wasting and edema. They usually have mild cutaneous and hair manifestations and an enlarged palpable fatty liver.



Kwashiorkor	Marasmus
It develops in children whose diets are deficient of protein.	It is due to deficiency of proteins and calories.
It occurs in children between 6 months and 3 years of age.	It is common in infants under 1 year of age.
Subcutaneous fat is preserved.	Subcutaneous fat is not preserved.
Oedema is present.	Oedema is absent
Enlarged fatty liver.	No fatty liver.
Ribs are not very prominent.	Ribs become very prominent.
Lethargic	Alert and irritable.
Muscle wasting mild or absent.	Severe muscle wasting
Poor appetite.	Voracious feeder.
The person suffering from Kwashiorkor needs adequate amounts of proteins.	The person suffering from Marasmus needs adequate amount of protein, fats and carbohydrates.

Figure 51: A brief comparison between kwashiorkor and marasmus

Symptoms of wasting

1. Weight loss : Most people who are malnourished will lose weight, but it s possible to be a healthy weight or even overweight and still be malnourished.
2. Reduced appetite lack of interest in food and drink.
3. Feeling tired all the time feeling weaker.
4. Getting ill often and taking a long time to recover wounds taking a long time to heal .
5. Poor concentration
6. Feeling cold most of the time
7. Low mood or depression
8. Not growing or putting on weight at the expected rate (faltering growth) in children

sign of wasting

1. Decreased fat mass. Fat secretes multiple hormones, including leptin, which may have a stimulating effect on the immune system. (Briend, 2019)
2. Depressed immunity resulting from low fat stores may also contribute to the increased mortality observed in wasting. (Briend, 2019)
3. Greatly reduced muscle mass is characteristic of severe wasting , and may represent a common mechanism linking wasting. (Briend, 2019)
4. Loss of body tissues resulting in wasting is a common phenotype for several different conditions which can be caused by a combination of reduced food intake, excessive requirements, altered metabolism, sepsis, trauma, ageing and inactivity. (Khursheed, N, 2012)

Diagnosis of wasting

1. low weight for height/length (Z_score below _3SD) (Poket book of hospital cara of children, 2013)

Figure 52: An illustration depicting the difference between being normal, wasted, and stunted.

2. mid _upper arm circumference below 115mm (Poket book of hospital cara of children, 2013)

Figure 53: A child having a MUAC measurement in the clinic; the child suffers from SAM.

3. presence of omitting edema always starts from the feet and extends upwards to other parts of the body (Poket book of hospital cara of children, 2013)

Figure 54: The child has omitting edema.

Investigation of wasting

1. Laboratory investigations may be helpful in the diagnosis of primary acute malnutrition and are essential in driving treatment in secondary malnutrition
2. fat distribution :circumferences measured midway between superior iliac crest and lower border of rib cage, and at greater trochanters, respectively)
3. measures the weight, Current weight, Weight 2 weeks, 1 month and 6 months ago, Assessment of degree of change
4. measures the current food intake, Quantity of food and if any change, Quality of food taken, Whether normal food is being eaten, Avoidance of specific food types (e.g. solids).
5. measures the symptoms that interfere with eating، Oral ulcers or oral pain، Difficulties swallowing، Nausea/vomiting، Early satiety، Alteration in bowel habit، Abdominal pain .
6. measures the activity levels/performance status, Normal activity, Slightly reduced activity, Inactive < 50% of the time ,inactive most of the time
7. test:
    a) Hematology: CBC.
    b) Biochemistry: Na, K, Mg, Ca, LFT, KFT& RBC
    c) Microbiology: Urine, stool& blood or cannula C/
    d) Radiology: CXR, Abdominal U/S, Echocardiography
    e) To support the diagnosis: Plasma proteins: Decreased total plasma proteins (normal 6-8 gm/dl)،Decreased albumin (normal 3.5-5 gm/dl).Non essential / essential amino acids (normally ≤2,between 2-3 in subclinical cases)

To detect complications: Monitor blood glucose closely ,CBC for anemia and leukocytosis in infection ,Sepsis workup e.g. CBC with differential, CRP, urinalysis, stool analysis , blood culture.

Management strategies for acute malnutrition

depend on the type of malnutrition, identification of its cause, and its severity.

Figure 55: Some depictions of how anthropometry is done for children with wasting. Some images show the use of MUAC and others the use of a weight to measure the child's weight

I. Primary Acute Malnutrition

- In moderate acute malnutrition, management at home is recommended, including counseling of parents, with emphasis on continuing breastfeeding and appropriate complementary feeding (nutrition-specific interventions). Ideally, these children should receive 25 kcal/kg per day of energy in excess of what their healthy peers receive, and their diets should contain animal-source foods rich in essential fatty acids and micronutrients including vitamin A, iron and zinc (Koletzko, B., 2025).

- Children with severe acute malnutrition without any complications can be managed in the community with ready-to-use therapeutic food (peanut paste, milk powder, vegetable oil and a mineral and vitamin mix as per WHO recommendations) can also be treated in the hospital with ready-to-use therapeutic food. (Koletzko, B., 2025)

- Severe acute malnutrition complications (i.e., severe diarrhea, hypoglycemia, hypothermia, pneumonia, urinary tract infection, sepsis, etc.) require hospitalization until children are ready to continue management at home (UNICEF, 2015), The stabilization phase of treatment for complications includes (Koletzko, B., 2025):

    1. Treat hypoglycemia with oral or intravenous glucose if the child is lethargic, unconscious or convulsing;
    2. Treat and prevent hypothermia;
    3. Treat shock;

4. Treat and prevent dehydration (preferably with the special rehydration solution for malnutrition. (Koletzko, B., 2025)

II. Secondary Acute Malnutrition

- For the management of secondary acute malnutrition, it is crucial to identify the underlying disease by history taking, examination and laboratory investigations.
- The principles of management of severe malnutrition resulting from the underlying diseases mentioned above are similar to those for primary severe acute malnutrition.

Prevention of wasting

- Prevention is a new area for WHO guideline development around wasting in infants and children. It can include prevention of wasting incidence, or of progression from moderate to severe wasting for instance. Importantly, appropriateness and effectiveness of prevention approaches may differ by setting, context, and other factors which will be considered for this guideline. (www.who.int, n.d.)
- Preventative solutions, such as better water and sanitation and food and health service access during pregnancy and childhood, are needed to address the underlying causes of malnutrition. Dietary diversification, supplementation, and food fortification interventions are used to prevent undernutrition. (www.who.int, n.d.)
- Children small for gestational age have been found to have over two-fold risk of wasting compared to children adequate for gestational age, pointing toward pregnancy related exposures.

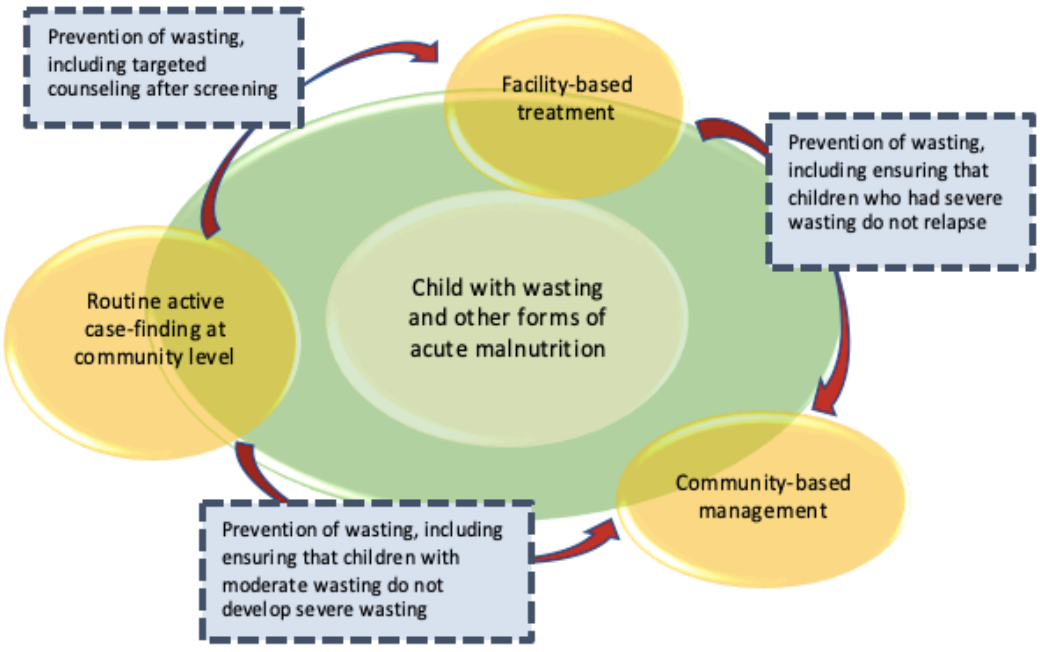

Prevention of wasting, including targeted counseling after screening
Facility-based treatment
Prevention of wasting, including ensuring that children who had severe wasting do not relapse
Routine active case-finding at community level
Child with wasting and other forms of acute malnutrition
Community-based management
Prevention of wasting, including ensuring that children with moderate wasting do not develop severe wasting

Figure 56: A scheme for to how to prevent the development of wasting.

Nutrition Intervention of wasting

Supply all pregnant women with prenatal vitamins

- Despite the proven benefits of supplying pregnant women with a full dosage of multiple-micronutrient supplements (MMS) . MMS increases the chances a baby will be born at a healthy weight and survive to his or her second birthday.

Support breastfeeding mothers

- Babies get the best start at life when they drink nothing but breastmilk until they are 6 months old, and continue breastfeeding until they are 2 years old while also consuming other nutritious complementary foods, only 41% of babies around the world are exclusively breastfed. One-to-one and group breastfeeding counselling helps provide mothers with the support they need to reach their breastfeeding goals.

Continue large-scale Vitamin A Supplementation

- Supplying a child with two high doses of Vitamin A every year is one of the most cost-effective ways to protect children from blindness, diarrhea, and other fatal illnesses.

Expand coverage of specialized foods for treatment RUTF

- The first priority of any nutrition program should be to make wasting treatment unnecessary by preventing children from ever becoming wasted. Unfortunately millions of children every year still .

Chapter 6

Chapter 6 91

Micronutrient deficiency-related malnutrition 92

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Micronutrient deficiency-related malnutrition

Definition

Inadequacies in intake of vitamins and minerals often referred to as micronutrients, can also be grouped together. Micronutrients enable the body to produce enzymes, hormones, and other substances that are essential for proper growth and development.

Types

- **Water soluble vitamins**
  Most of the vitamins can be dissolved in water. They are difficult to store in the body and get flushed out in urine when consumed in large quantities. They play an important role in producing energy. Since they are not stored in the body, it is important to take them enough from different food sources.
- **Fat-soluble vitamins**
  These are stored in the liver and fatty tissues for future use. Vitamins A, D, E, and K are important fat-soluble vitamins. They play a major role in the proper functioning of the immune system, proper bone development, proper vision, and protection of cells from damage.
- **Macro-minerals**
  These are required in higher amounts as compared to the trace minerals. Some of these minerals include calcium, magnesium, phosphorus, sodium, chloride.
- **Trace minerals**
  These are required in very small amounts, but perform various important functions in our body. Iron, manganese, copper, zinc, iodine, fluoride, and selenium are some of the important trace minerals required by the body.

But the important vitamins and minerals that related to diet are: iron, zinc and iodine & vit.A, vit.B12 and vit.B9.

Micronutrient deficiencies can be caused by a variety of factors. Some common causes include:

1. a lack of access to a healthy diet containing diverse foods
2. poor nutrition education
3. inadequate food fortification and supplementation.

Epidemiology

In terms of epidemiology, micronutrient deficiencies are a global health issue affecting approximately 2 billion people worldwide. Low- and middle-income countries bear a

disproportionate burden of micronutrient deficiencies. Widespread global micronutrient deficiencies exist, with pregnant women and their children under 5 years at the highest risk. Iron, iodine, folate, vitamin A, and zinc deficiencies are the most widespread micronutrient deficiencies, and all these MNDs are common contributors to poor growth, intellectual impairments, perinatal complications, and increased risk of morbidity and mortality. Iron deficiency is the most common micronutrient deficiencies worldwide and leads to microcytic anemia, decreased capacity for work, as well as impaired immune and endocrine function.

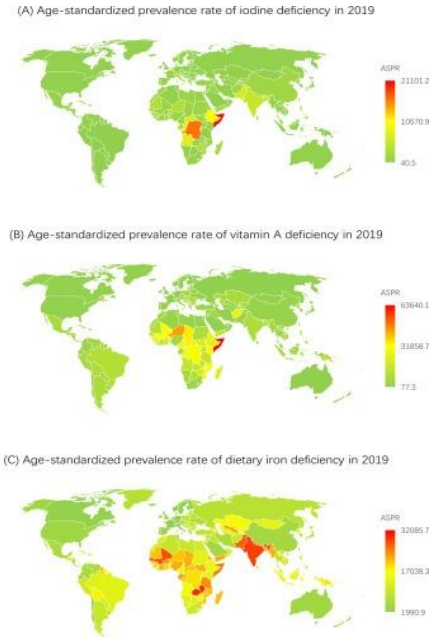
(A) Age-standardized prevalence rate of iodine deficiency in 2019
(B) Age-standardized prevalence rate of vitamin A deficiency in 2019
(C) Age-standardized prevalence rate of dietary iron deficiency in 2019

Figure 57: Age-standardized prevalence of iodine, vitamin A, and iron deficiencies in 2019 worldwide.

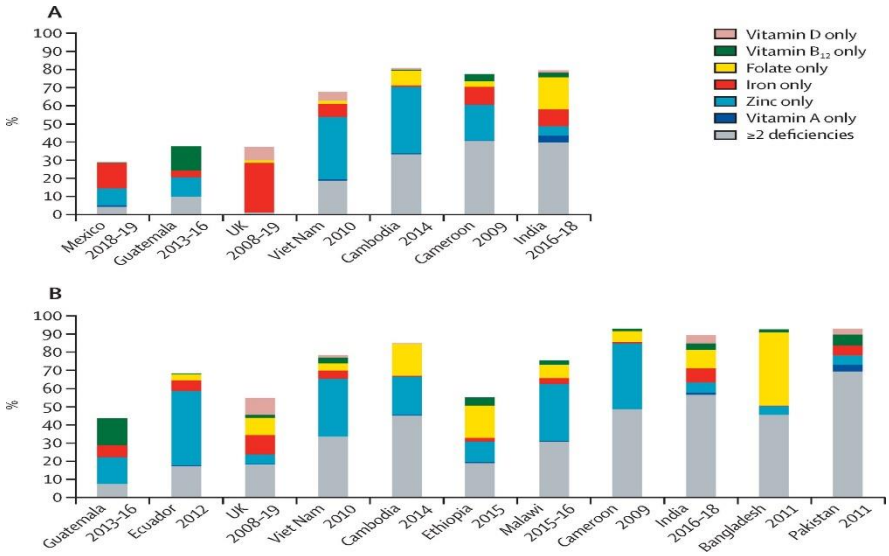

Figure 58: Prevalence of single or two or more micronutrient deficiencies in preschool-aged children aged 6-59 months (A) and non-pregnant women aged 15-49 years (B)

Pathophysiology

- **Anemia (Iron and Vitamin B12 deficiency):**

  Anemia is a condition whereby an individual's blood lacks enough red blood cells (RBCs) to carry oxygen efficiently around the body. Anemia can result from a lack of iron or vitamin B12 (pernicious anemia), although iron deficiency is the most common type (This can happen due to blood loss, inadequate dietary intake, or insufficient iron delivery to bone marrow.

  Globally, anemia affects more people than any other health problem. Anemia has important implications for general productivity and development, reducing the work capacity of individuals by up to 20 percent. In more serious cases, anemia can lead to

exacerbation of disease and illness. The World Health Organization estimate that 20 percent of maternal deaths are attributed to anemia alone.

- **Folic acid deficiency anemia:**

  Also known as folate deficiency anemia, is a type of anemia that results from a deficient intake of folic acid (folate), a B vitamin. Folic acid is needed for the formation of heme, the pigmented, iron-containing portion of the hemoglobin in red blood cells. Low levels of folic acid can cause megaloblastic anemia, where red blood cells are larger than normal and there are fewer of these cells. This can occur due to inadequate dietary intake of folic acid or malabsorption.7

- **Vitamin A deficiency:**

  Vitamin A has a role in the regeneration of visual pigment, maintenance of mucosal membranes, and immune function. Deficiency can lead to night blindness due to poor regeneration of visual pigment in retinal rods. If the deficiency is allowed to persist, the rods will degenerate, and xerophthalmia will develop, leading to true blindness.8,9,10 Intestinal and pulmonary mucosal membrane xerosis and breakdown, along with immune dysfunction, lead to frequent infections and anemia of chronic inflammation. VAD also serves to exacerbate serious disease and illness, leading to increased rates of maternal and childhood mortality.

- **Zinc deficiency:**
  - Zinc deficiency can have a number of negative health consequences, affecting the central nervous, gastrointestinal, immune, epidermal, reproductive, and skeletal systems.
  - Zinc is an essential nutrient for growth and recovery; deficiencies can therefore stunt growth; increase susceptibility to disease and infection; increase recovery time, or in some cases, impair recovery; reduce mental capacity; and increase the prevalence of maternal, neonatal and child complications.
  - Higher morbidity and mortality in mothers and newborns is associated with high prevalence of zinc deficiency
  - Zinc is involved in molecular synthesis, including the formation of DNA, RNA, and proteins. It stabilizes ribosomes, cell membranes and has protective effects by decreasing lipid peroxidation and subsequent free radicals. Beyond the molecular nuances of function, it is required for spermatogenesis, embryogenesis, and fetal growth.15,16 The absorption of zinc occurs primarily in the distal duodenum and proximal jejunum, while excretion is primarily gastrointestinal (GI) with some secretion through urine and sweat.

- Its role in immune function is also well described. Overall, it keeps the skin viable as an initial barrier to pathogens. It mediates innate immunity with the function of natural killer cells and neutrophils while influencing the acquired immune system through T-lymphocyte activation and regulation, Th1 cytokine production, B-lymphocyte function, and antibody production with subsequent immunoglobulin G formation. Macrophages utilize zinc for phagocytosis, intracellular killing, and cytokine production. Zinc potentiates programmed cell death through apoptosis.

- **Iodine deficiency:**
  - An inadequate dietary intake of iodine leads to insufficient production of thyroid hormones, which affects many parts of the body, particularly muscle, heart, liver, kidney and the developing brain. Inadequate hormone production adversely affects these tissues, resulting in the disease states known collectively as iodine deficiency disorders, or IDD. Dietary iodine deficiency stimulates TSH secretion, which results in thyroid hypertrophy. The enlargement of the thyroid gland due to dietary iodine deficiency is called endemic goiter. Iodine intakes consistently lower than 50 µg/day usually result in goiter. Severe and prolonged iodine deficiency, may lead to a deficient supply of thyroid hormones. This condition is referred to as hypothyroidism.
  - Severe iodine deficiency can lead to brain damage and during pregnancy can cause a number of issues including stillbirth, spontaneous abortion and congenital anomalies. Less severe iodine deficiency may still cause mental impairment that reduces intellectual capacity.

Clinical picture

- Iron and vitamin B12 deficiency:
  - Fatigue
  - Skin pallor
  - Paresthesia in hands and feet
  - Glossitis
  - GIT manifestations include diarrhea, bloating, constipation, nausea.
  - Weight loss
  - Mood changes including depression, psychosis and irritability
- Vitamin A deficiency:
  - Night blindness
  - Dry skin
  - Dry eyes

- Infertility or trouble conceiving
- Delayed growth
- Poor wound healing
- Acne breakouts

- Zinc deficiency:
  - Unexplained weight loss
  - Lack of alertness
  - Decrease in sense of taste and smell
  - Loss of appetite
  - Poor wound healing
  - Delay in growth
  - Vision problems
- Iodine deficiency:
  - Goiter
  - Symptoms of hyperthyroidism or hypothyroidism
  - Fatigue
  - Hair loss
  - Dry skin
  - Still birth or jeopardizes children's mental health and often their very survival.

Investigation

Iron-deficiency anemia diagnosis:

To diagnose iron deficiency anemia, your doctor may run tests to look for:

1. for Iron deficiency:
   - Red blood cell size and color. With iron deficiency anemia, red blood cells are smaller and paler in color than normal.
   - Hematocrit. This is the percentage of your blood volume made up by red blood cells. Normal levels are generally between 35.5 and 44.9 percent for adult women and 38.3 to 48.6 percent for adult men. These values may change depending on your age.
   - Hemoglobin. Lower than normal hemoglobin levels indicate anemia. The normal hemoglobin range is generally defined as 13.2 to 16.6 grams (g) of hemoglobin per deciliter (dL) of blood for men and 11.6 to 15 g/dL for women.
   - Ferritin. This protein helps store iron in your body, and a low level of ferritin usually indicates a low level of stored iron.

Healthy and Low Iron Studies in Adults		
Iron, µmol/L	Normal	10 to 30
	Iron-deficiency anemia	Less than 10
Ferritin, µg/L	Normal	Men 40 to 300 Women 20 to 200
	Iron-deficiency anemia	Less than 10

Table 13: Laboratory values of iron in ferritin in normal conditions and in iron deficiency anemia

2. for Vitamin B12 deficiency

   Schilling Test: The Schilling test is conducted to determine the body's ability to absorb vitamin B12. It involves the administration of a small amount of radioactive vitamin B12, which is then measured in the urine. This test is rarely used today due to the availability of more accurate blood tests.

Diagnosis

According to the type of vitamins and minerals deficiency

- **Diagnosis of iodine deficiency**
  - Blood tests
  - Presence of a goiter (in adults):

    Iodine deficiency is diagnosed based on blood tests indicating low levels of thyroid hormones or a high level of thyroid-stimulating hormone (TSH) or based on the presence of a goiter (only in adults).

    Doctors do a blood test to check for hypothyroidism, including that due to iodine deficiency, in all newborns.

    Imaging tests, such as ultrasonography or thyroid scanning, may be done to measure the thyroid gland and to evaluate any abnormalities
- **Diagnosis of zinc deficiency**

  Because the symptoms of zinc deficiency are non-specific, it may be difficult to diagnose. Many of the symptoms associated with zinc deficiency are also symptoms of other nutritional deficiencies and medical problems. For example, infections, anemia, and thyroid disease often cause symptoms similar to those of zinc deficiency. You should discuss your concerns with your healthcare provider, who will take a detailed medical history and physical examination. You may also need diagnostic tests (as part of your evaluation) a) zinc level checked. The normal reference range is 0.60-

1.20 mcg/mL for children under age 10 and under. The normal range for children over age 10 and adults is 0.66-1.10 mcg/mL.

- **Diagnosis of vitamin A deficiency**

  Your healthcare provider can diagnose vitamin A deficiency based on your symptoms and a blood test.

  1. Symptoms:

     If you have night blindness, your healthcare provider may order an eye test called electroretinography. Your healthcare provider will examine the light-sensing cells (photoreceptors) in your retinas. The test measures the response of your retinas to flashes of light.

     Dark adaptation test: This test measures the ability of the eyes to adjust to dim light. A person with vitamin A deficiency may have difficulty adjusting to low light.

  2. Blood tests

     a. serum retinol blood test can measure the amount of vitamin A in your blood. However, your body stores large amounts of vitamin A, so the level of vitamin A in your blood won't decrease until your deficiency is severe (less than 20 micrograms per deciliter [mcg/dL]).

  Vitamin A deficiency can be confirmed if your symptoms start to improve after taking a vitamin A supplement

Management and Prevention

The treatment and prevention for micronutrient related malnutrition is a supplement of all important vitamins and minerals, or divided according to vitamins and minerals types deficiency, as:

- **Anemia (Iron and vitamin B12 deficiency):**

  For iron-deficiency anemia, your doctor may recommend prescription supplements such as iron supplements to increase the iron in your body. Vitamin B12 supplements or shots can help treat vitamin B12–deficiency anemia.

  Iron deficiency Treatment

  To treat iron deficiency anemia, your doctor may recommend that you take iron supplements. Your doctor will also treat the underlying cause of your iron deficiency, if necessary.

  - Iron supplements

    Your doctor may recommend over-the-counter iron tablets to replenish the iron stores in your body. Your doctor will let you know the correct dose for you. Iron is also available in liquid form for infants and children. To improve the chances that your body will absorb the iron in the tablets, you may be instructed to:

1. Take iron tablets on an empty stomach. If possible, take your iron tablets when your stomach is empty. However, because iron tablets can upset your stomach, you may need to take your iron tablets with meals.
2. Don't take iron with antacids. Medications that immediately relieve heartburn symptoms can interfere with the absorption of iron. Take iron two hours before or four hours after you take antacids.
3. Take iron tablets with vitamin C. Vitamin C improves the absorption of iron. Your doctor might recommend taking your iron tablets with a glass of orange juice or with a vitamin C supplement.

Iron deficiency can't be corrected overnight. You may need to take iron supplements for several months or longer to replenish your iron reserves. Generally, you'll start to feel better after a week or so of treatment. Ask your doctor when to have your blood rechecked to measure your iron levels. To be sure that your iron reserves are replenished, you may need to take iron supplements for a year or more.

Treating underlying causes of iron deficiency

If iron supplements don't increase your blood-iron levels, it's likely the anemia is due to a source of bleeding or an iron-absorption problem that your doctor will need to investigate and treat. Depending on the cause, iron deficiency anemia treatment may involve:

1. Medications, such as oral contraceptives to lighten heavy menstrual flow
2. Antibiotics and other medications to treat peptic ulcers
3. Surgery to remove a bleeding polyp, a tumor or a fibroid

If iron deficiency anemia is severe, you may need iron given intravenously or you may need blood transfusions to help replace iron and hemoglobin quickly.

- **Management of Iodine deficiency**
  - Prevention

    At a population level, iodine deficiency disorder (IDD) can be prevented by the iodization of food products or the water supply. In practice, this is usually achieved by iodization of salt. An alternative in some developing countries has been the periodic injection of iodized oil supplements.
  - Iodine deficiency treatment

    It is usually treated through eating more foods containing iodine, using iodised salt and taking iodine supplements.

    People with hypothyroidism are usually treated with a synthetic form of the thyroid hormone, which they will need to take for the rest of their lives.
- Zinc-deficiency management
  - Prevention

The best way to avoid zinc deficiency for most people is to eat foods that are high in zinc. These include oysters, meat and fish. Smaller amounts of zinc can be found in cereals, legumes, dairy foods and seeds.

- Zinc deficiency treatment

  Extra zinc can be obtained from a supplement, usually in the form of a pill or capsule. Your doctor will recommend the right dose for you, depending on your symptoms. Zinc can also be obtained from some multi-vitamin supplements or cold remedies that contain zinc.

  It's important to follow your doctor's or pharmacist's recommendations, as having too much zinc can lead to diarrhoea or vomiting, and can interfere with other nutrients you need such as copper and iron. You should not take more than 40mg of extra zinc a day, unless your doctor tells you to.

- Vitamin A deficiency management
  - Prevention

    The best way to prevent vitamin A deficiency is to eat a healthy diet that includes foods that contain vitamin A. Vitamin A can be found naturally in:

    1. Green vegetables, such as leafy greens and broccoli.
    2. Orange and yellow vegetables, such as carrots, pumpkin, sweet potatoes and squash.
    3. Orange and yellow fruits, such as oranges, mangos, cantaloupe and papayas.
    4. Dairy products.
    5. Liver, beef and chicken.
    6. Certain types of fish, such as salmon.
    7. Eggs.
    8. Cereals, rice potatoes, wheat and soybeans fortified with vitamin A.
  - If necessary, you can also take a vitamin A supplement.

Chapter 7

Chapter 7	**100**
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Overweight

• Definition:

Overweight is a real global public health concern , it's described as weight that is higher than whats normal for a given hight , i.e BMI ranges between 25 — < 30 kg/m^2.

Epidemiology:

The epidemic of overweight presents a major challenge to chronic disease and health across the life around the world , affecting over a third of the world's population , If secular trends continue, by 2030 an estimated 38% of the world's adult population will be overweight and another 20% will be obese . Fueled by economic growth, industrialization, mechanized transport, urbanization, an increasingly sedentary lifestyle, and a nutritional transition to processed foods and high calorie diets

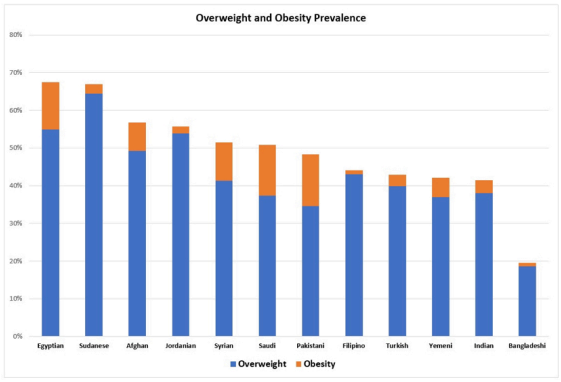

Figure 59: Percentages of overweight & obese individuals in various Arabian nations, and Bangladesh.

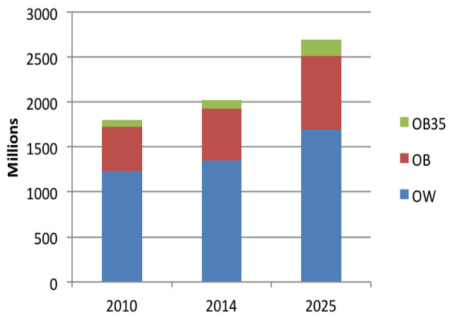

Figure 60: approximate number of overweight, and obese individuals in the world.

Causes:

Gaining excess weight can be caused by several factors including :

High- calorie food intake : having a diet rich in calories while being physically inactive causes weight gain .

Lack of physical activity: lack of physical activity and sedentary life style have a bad impact on body weight and overall health in general.

Metabolic disorders: metabolic dysfunction such as insulin resistance or hypothyroidism decreases the ability pf body (i.e metabolism) to burn fat .

Emotional and mental issues: studies have proven that emotional and mental disorders are strongly associated with being overweight , for example : people suffering from depression or anxiety relieve theirselves by emotional/ binge eating therefore gaining extra weight .

Medications : some medications such as corticosteroids, anti-depressants and contraceptive pills cause weight gain .

Pathophysiology:

Regular homeostasis regarding body weight is maintained by balance between fat storage and energy utilization, if this balance is disrupted by any factor it contributes to hormonal , reproductive and developmental abnormalities such as : Diabetes mellitus ,hypertension, Cardiovascular diseases , insulin resistance …etc .

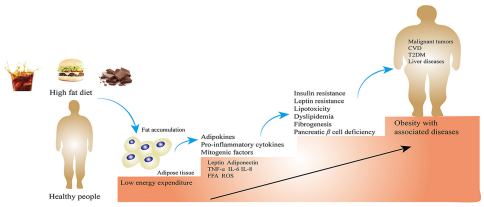

Figure 61: A diagram explaining the pathophysiology of being overweight.

Symptoms and signs :

Excess weight can have a negative impact on peoples health in various way :

Symptoms:

1. Back and / or joint pain .
2. Shortness of breath (dyspnea).
3. Excessive sweating .
4. Heat intolerance .
5. Drowsiness and fatigue.
6. Depression and low self-esteem regarding appearance.

Signs:

1. BMI higher than 25 and lower than 30 kg /m2 .
2. Waist circumference more than 94 in men and more than 88 in women .
3. Acanthosis nigracins (That's hyperpigmentation of skin folds like neck and armpits).
4. Stretch marks / striae alba : due to distention of skin.
5. Swelling of lower limbs and appearance of varicose veins .

Investigation:

The role of laboratory and other investigations is to exclude possible underlying causes of obesity and its complications, these tests include:

A. Biochemical profile (renal , bone , liver).
B. Full blood count.
C. Fasting plasma glucose and lipid profile.
D. Serum free thyroxine and TSH .
E. Electrocardiogram (to exclude any CVS diseases).
F. Plasma leptin (It's not routinely indicated but may be useful in suspected cases of leptin deficiency.

Diagnosis:

Overweight is diagnosed by some exams and tests include:

1. Taking health history .
2. A physical exam (To measure height , vital signs) .
3. Calculating BMI .
4. Measuring waist circumference.

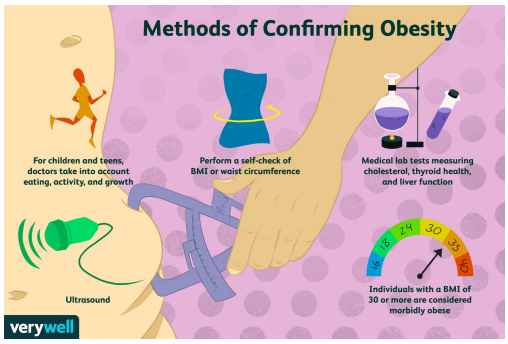
Methods of Confirming Obesity
For children and teens, doctors take into account eating, activity, and growth
Perform a self-check of BMI or waist circumference
Medical lab tests measuring cholesterol, thyroid health, and liver function
Ultrasound
Individuals with a BMI of 30 or more are considered morbidly obese
verywell

Figure 62: Illustration for how to confirm being obese.

Management:

Weight management helps people to lose weight or keep it managed, Some tips can be used :

1. Eating healthy diet .
2. Physical activity .
3. Changing bad habits .

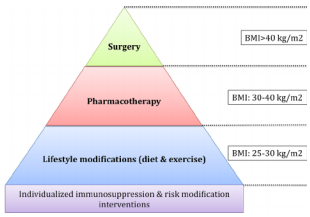

Figure 63: Treatment options for different ranges in the BMI scale pertaining to being overweight and obese.

Prognosis and Prevention of over-nutrition

Prevention [α]

- Preventing the consequences of over nutrition is more efficient and effective than dealing with them later on, so here are some tips for avoiding the risk and effects of over eating :
- Incorporating a healthy life style by changing bad eating habits and limiting intake of processed food .
- Adding fiber-rich foods to your diet to keep you full as long as possible.
- Don’t skip meals. You would think that its healthier but it will actually cause intense hunger , therefore resulting in episodes of overeating.
- Eat in smaller portions and make sure to chew food slower to fill you up faster.
- In case of emotional/binge eating disorder, avoid stress and any food triggers and seek medical help from a professional psychologist if needed. (Wohlfahrt-Veje, C. et al., 2014)
- Stay hydrated to avoid false/fake hunger.
- Avoid snacking and try to control your cravings by switching to fruits and vegetables.
- Limit foods that are the easiest to overeat, these include foods high in salt, added sugar and saturated fats.
- Keep your body moving. Maintaining and improving your fitness will show you significant change in both your physical and mental health.

Prognosis β

People who have overweight or obesity, compared to those with healthy weight, are at increased risk for many serious diseases and health conditions. These include :

- Type 2 diabetes

  Of all physical health problems, type II diabetes has the strongest association with obesity. About 8 out of 10 people with type 2 diabetes are overweight or have obesity. Over time, high blood glucose leads to problems such as heart disease, stroke, kidney disease, eye problems, nerve damage, and other health problems. If you are at risk for type 2 diabetes, losing 5 to 7 percent of your body weight and getting regular physical activity may prevent or delay the onset of type 2 diabetes.

- cardiovascular diseases

  Obesity predisposes to a number of cardiovascular risks including hypertension, dyslipidemia, atherosclerosis, coronary heart disease, etc…

- Metabolic syndrome

  Metabolic syndrome is a group of conditions that put you at risk for heart disease, diabetes, and stroke. These conditions are high blood pressure, high blood glucose levels, high triglyceride levels in your blood, low levels of HDL cholesterol and too much fat around your waist.

- Osteoarthritis

  Being overweight or having obesity may raise your risk of getting osteoarthritis by putting extra pressure on your joints and cartilage.

- Gallbladder diseases

  Overweight and obesity may raise your risk of getting gallbladder diseases, such as gallstones and cholecystitis. Imbalances in substances that make up bile cause gallstones. Gallstones may form if bile contains too much cholesterol.

- Fatty liver disease

  Overweight and obese people are at a higher risk of developing fatty liver disease due to Buildup of fat in the liver . Fatty liver can lead to serious liver damage and cirrhosis.

- Pregnancy problems

  Overweight and obesity raise the risk of health problems that may occur during pregnancy. Pregnant women who are overweight or obese may have a greater chance of developing gestational diabetes and pre-eclampsia.

- mental disorders (Lawlor D.A. et al., 2010; Flegal K.M. & Graubard B.I., 2009)

  Overweight and obesity are associated with mental health problems such as depression. People who deal with overweight and obesity may also be the subject of weight bias and stigma from others. This can lead to feelings of rejection, shame, or guilt—further worsening mental health problems.

- Cancer

Patients who are obese have an increased risk of cancer. 41% of cases of uterine cancer and more than 10% of gallbladder, kidney, liver, and colon cancers were attributable to being obese.

- Obstructive Sleep Apnea (Freedman, D.S. et al., 2010)

  It is defined as complete obstruction of the airway during sleep despite normal efforts to breathe. This has widespread effects on the body, particularly cardiovascular and metabolic effects.

α: (Garrow, J.S. & Webster, J, 1985; Freedman, 2013)
β: (Steinberger, J. et al., 2005; Sun, Q. et al., 2010)

Chapter 8

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Obesity

Definition

Obesity, medical condition characterized by storage of excess body fat. The human body naturally stores fat tissue under the skin and around organs and joints.

The World Health Organization (WHO) defines obesity as “a condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired”

the accumulation of too much fat in the body is associated with a variety of health problems. Studies show that individuals who are overweight or obese run a greater risk of developing diabetes mellitus, hypertension, coronary heart disease, stroke, arthritis, and some forms of cancer.

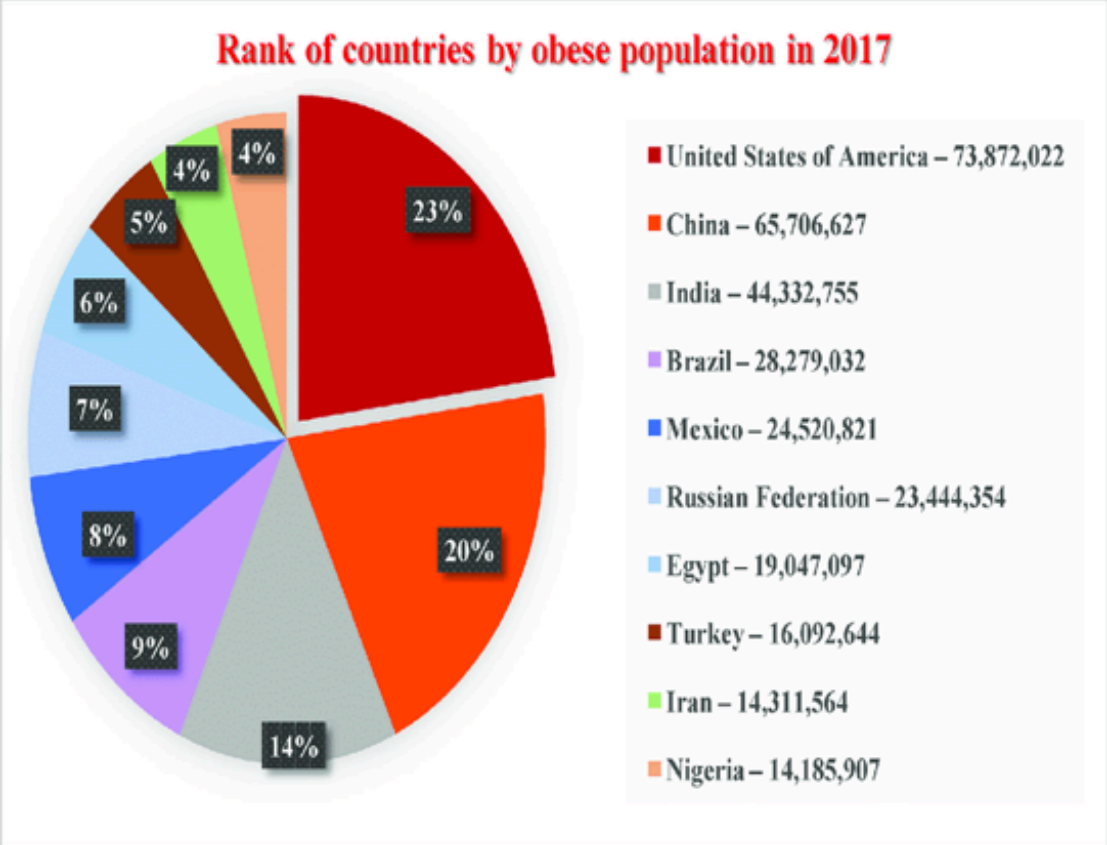

Figure 64: Pie chart for the countries with the largest contribution of obesity.

Epidemiology

Obesity, although recognized millennia ago as an unusual feature and a societal handicap, only since the 1980s has it become a major clinical and public health problem. Originally a disease of affluence it became evident in poorer countries in the 1990s with children then showing increasing evidence of their excess weight gain with all its propensities to premature disease and death. In 1997, the WHO formally recognized obesity as a global

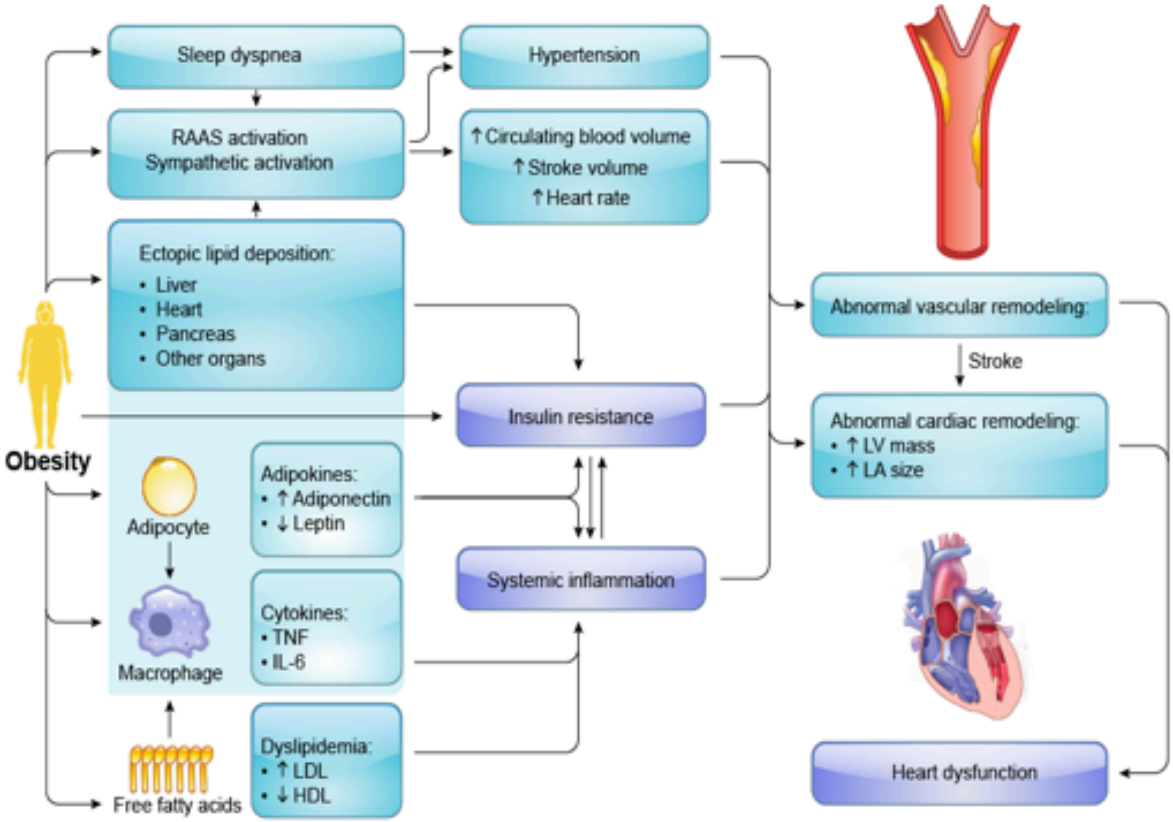

Figure 65: How obesity contributes to causing cardiovascular dysfunction.

epidemic. As of 2008, the WHO estimates that at least 500 million adults (greater than 10%) are obese, with higher rates among women than men.

The global prevalence of obesity more than doubled between 1980 and 2014. In 2014, more than 600 million adults were obese, equal to about 13 percent of the world's adult population. The percentage of adults affected in the United States as of 2015-2016 is about 39.6% overall (37.9% of males and 41.1 % of females). In 2000, the World Health Organization (WHO) stated that overweight and obesity were replacing more traditional public health concerns such as undernutrition and infectious diseases as one of the most significant cause of poor health.

Causes

Obesity has individual, socioeconomic, and environmental causes. Some known causes are diet, physical activity, automation, urbanization, genetic susceptibility, medications, mental disorders, economic policies, endocrine disorders, and exposure to endocrine-disrupting chemicals

Although there are genetic, behavioral, meta

.bolic and hormonal influences on body weight,

In the United States, most people's diets are too high in calories — often from fast food and high-calorie beverages.
People with obesity might eat more calories before feeling full, feel hungry sooner, or eat more due to stress or anxiety.

Many people who live in Western countries now have jobs that are much less physically demanding, so they don't tend to burn as many calories at work. Even daily activities use fewer calories, courtesy of conveniences such as remote controls, escalators, online shopping and drive-through banks.

Pathophysiology

Obesity is an exaggeration of normal adiposity and is a central player in the pathophysiology of diabetes mellitus, insulin resistance, dyslipidemia, hypertension, and atherosclerosis, largely due to its secretion of excessive adipokines. Obesity is a major contributor to the metabolic dysfunction involving lipid and glucose, but on a broader scale, it influences organ dysfunction involving cardiac, liver, intestinal, pulmonary, endocrine, and reproductive functions. Inflammatory, insulin-resistant, hypertensive, and thrombotic-promoting adipokines, which are atherogenic

Risk factors

Obesity usually results from a combination of causes and contributing factors:

1. Family inheritance and influences: The genes you inherit from your parents may affect the amount of body fat you store, and where that fat is distributed. Genetics may also play a role in how efficiently your body converts food into energy, how your body regulates your appetite and how your body burns calories during exercise.
2. Lifestyle choices: Unhealthy diet. A diet that's high in calories, lacking in fruits and vegetables, full of fast food, and laden with high-calorie beverages and oversized portions contributes to weight gain.
3. Liquid calories. People can drink many calories without feeling full, especially calories from alcohol. Other high-calorie beverages, such as sugared soft drinks, can contribute to significant weight gain.
4. Inactivity. If you have a sedentary lifestyle, you can easily take in more calories every day than you burn through exercise and routine daily activities. Looking at computer, and phone screens is a sedentary activity. The number of hours spent in front of a screen is highly associated with weight gain.

5. Certain diseases and medications: In some people, obesity can be traced to a medical cause, such as Prader-Willi syndrome, Cushing syndrome and other conditions. Medical problems, such as arthritis, also can lead to decreased activity, which may result in weight gain. Some medications can lead to weight gain if you don't compensate through diet or activity. These medications include some antidepressants, anti-seizure medications, diabetes medications, antipsychotic medications, steroids and beta blockers.

6. Social and economic issues: Social and economic factors are linked to obesity. Avoiding obesity is difficult if you don't have safe areas to walk or exercise. Similarly, you may not have been taught healthy ways of cooking, or you may not have access to healthier foods. In addition, the people you spend time with may influence your weight — you're more likely to develop obesity if you have friends or relatives with obesity.

7. Age: Obesity can occur at any age, even in young children. But as you age, hormonal changes and a less active lifestyle increase your risk of obesity. In addition, the amount of muscle in your body tends to decrease with age. Generally, lower muscle mass leads to a decrease in metabolism. These changes also reduce calorie needs and can make it harder to keep off excess weight. If you don't consciously control what you eat and become more physically active as you age, you'll likely gain weight.

8. Other factors

- Pregnancy. Weight gain is common during pregnancy. Some women find this weight difficult to lose after the baby is born. This weight gain may to the development of obesity in women.

- Quitting smoking. Quitting smoking is often associated with weight gain. And for some, it can lead to enough weight gain to qualify as obesity. Often, this happens as people use food to cope with smoking withdrawal. In the long run, however, quitting smoking is still a greater benefit to your health than is continuing to smoke. Your doctor can help you prevent weight gain after quitting smoking.

- Lack of sleep: Not getting enough sleep or getting too much sleep can cause changes in hormones that increase appetite. You may also crave foods high in calories and carbohydrates, which can contribute to weight gain.

- ▪Stress. Chronic stress can lead to “comfort eating,” which often involves the overeating of foods that are high in fat, sugar, and calories, which, in turn, can lead to weight gain.

- ▪Microbial: Your gut bacteria are affected by what you eat and may contribute to weight gain or difficulty losing weight.

- Even if you have one or more of these risk factors, it doesn't mean that you're destined to develop obesity. You can counteract most risk factors through diet,
- physical activity and exercise, andbehavior changes.

Clinical pictures

Symptoms of Obesity:

Some symptoms may increase the risk of developing certain diseases and disorders. In some cases, these may be life-threatening or even fatal. The American Medical Association considers obesity itself a disease that needs to be diagnosed and treated That's due to symptoms and complications that are common among people with obesity.

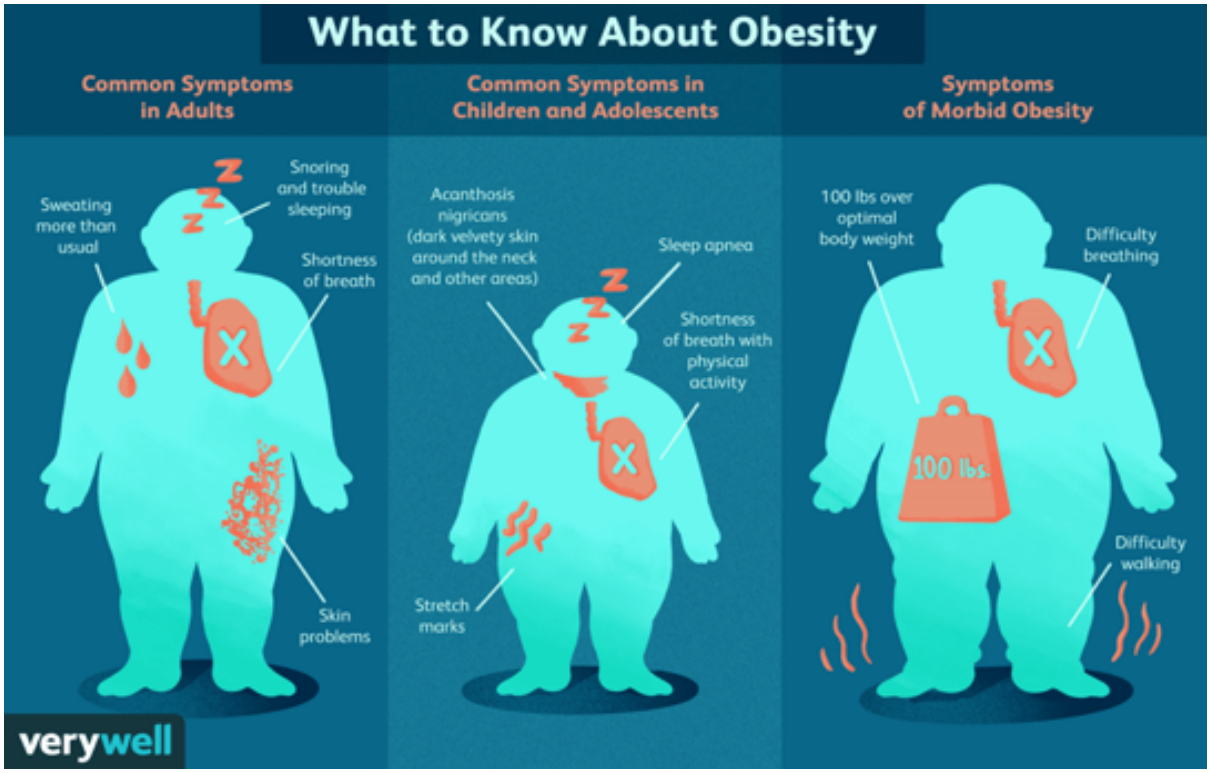

Figure 66: Common symptoms of obesity in different age groups, and symptoms of morbid obesity.

This article explains the difference between being overweight and having the disease of obesity. It also describes obesity signs and symptoms in children and adults, as well as possible complications.

Common Adult Obesity Symptoms

Common symptoms of obesity in adults include:

- Excess body fat, particularly around the waist
- Shortness of breath
- Sweating more than usual
- Snoring
- Trouble sleeping
- Skin problems from moisture accumulating in the folds
- Inability to perform simple physical tasks you could easily perform before weight gain
- Fatigue, which can range from mild to extreme
- Pain, especially in the back and joints
- Psychological issues such as negative self-esteem, depression, shame, and social isolation5

Common Childhood Obesity Symptoms

Figure 67: Complications of obesity.

Common childhood obesity symptoms may include:

•Fatty tissue deposits (may be noticeable in the breast area)
•Stretch marks on the hips and back
•Acanthosis nigricans (dark velvety skin around the neck and other areas)
•Shortness of breath with physical activity
•Sleep apnea
•Constipation
•Gastroesophageal reflux disease (GERD)
•Low self-esteem
•Early puberty in biological females delayed puberty in biological males
•Orthopedic problems, such as flat feet or dislocated hips

Childhood obesity rates vary between different groups. For example, children in lower-income

families are more likely to have obesity than those in high-income households

Complications

Obesity can contribute to many serious health disorders. Serious health complications that are more likely to occur with obesity include:

- High blood pressure (hypertension) or heart disease from the heart working harder to pump blood throughout the body
- High cholesterol levels (fatty deposits that can block arteries), which can lead to stroke, heart attack, and other complications
- Type 2 diabetes, which is directly linked to obesity in nearly 50% of cases
- Some types of cancer, which are linked to obesity in about 40% of cases
- Asthma, plus worse asthma symptoms
- and control, which leads to more hospitalizations and medication usage
- Obese asthma, which is a unique type of asthma found only in some people with obesity
- Kidney disease due to kidney damage from chronic high blood pressure
- Osteoarthritis from excess strain on the joints, bones, and muscles
- Gallbladder disease, which becomes 7% more likely with each step up on the BMI
- Sleep apnea from fat deposits in the neck and tongue that block airways
- GERD, hiatal hernia, and heartburn from excess weight
- pushing on the valve that's supposed to keep stomach contents out of the esophagus

Diagnosis

To diagnose obesity, your doctor will typically perform a physical exam and recommend some tests.

These exams and tests generally include:

Taking your health history. Your doctor may review your weight history, weight-

loss efforts, physical activity and exercise habits, eating patterns and appetite control, what other conditions you've had, medications, stress levels, and other issues about your health. Your doctor may also review your family's health history to see if you may be predisposed to certain conditions.

A general physical exam. This includes measuring your height; checking vital signs, such as heart rate, blood pressure and temperature; listening to your heart and lungs; and examining your abdomen.

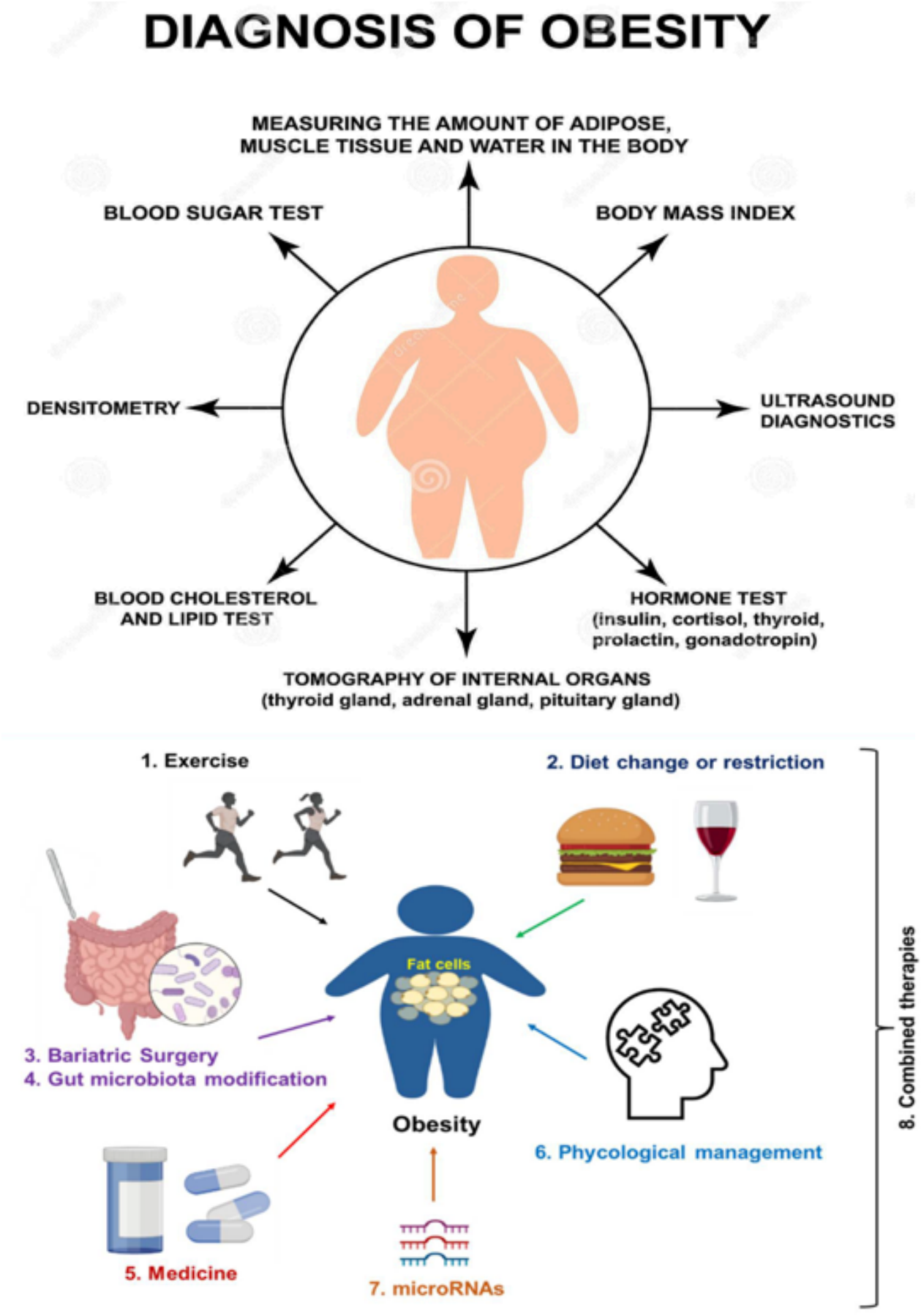

Figure 68: Diagnosis and possible therapies for obesity.

Calculating the BMI. Your doctor will check your body mass index (BMI). A BMI of 30 or higher is considered obesity. Numbers higher than 30 increase health risks even more. Your BMI should be checked at least once a year because it can help determine your overall health risks and what treatments may be appropriate.

Measuring your waist circumference. Fat stored around the waist, sometimes called visceral fat or abdominal fat, may further increase the risk of heart disease and diabetes.

Women with a waist measurement (circumference) of more than 35 inches (89 centimeters) and men with a waist measurement of more than 40 inches (102 centimeters) may have more health risks than do people with smaller waist measurements. Like the BMI measurement, waist circumference should be checked at least once a year.

Checking for other health problems. If you have known health problems, your doctor will evaluate them. Your doctor will also check for other possible health problems, such as high blood pressure, high cholesterol, underactive thyroid, liver problems and diabetes.
Gathering this information will help you and your doctor choose the type of treatment that will work best for you

Treatment

The goal of obesity treatment is to reach and stay at a healthy weight. This improves overall health and lowers the risk of developing complications related to obesity.

All weight-loss programs require changes in your eating habits and increased physical activity. The treatment methods that are right for you depend on your obesity severity, your overall health and your willingness to participate in your weight-loss plan.

Dietary changes

Reducing calories and practicing healthier eating habits are vital to overcoming obesity. Although you may lose weight quickly at first, steady weight loss over the long term is considered the safest way to lose weight and the best way to keep it off permanently.

Dietary changes to treat obesity include:

Cutting calories.

The key to weight loss is reducing how many calories you take in. The first step is to review your typical eating and drinking habits to see how many calories you normally consume and where you can cut back. You and your doctor can decide how many calories you need to take in each day to lose weight, but a typical amount is 1,200 to 1,500 calories for women and 1,500 to 1,800 for men.

Feeling full on less.

Some foods — such as desserts, candies, fats and processed foods — contain a lot of calories for a small portion. In contrast, fruits and vegetables provide a larger portion size with fewer calories. By eating larger portions of foods that have fewer calories, you reduce hunger pangs, take in fewer calories and feel better about your meal, which contributes to how satisfied you feel overall.

Making healthier choices. To make your overall diet healthier, eat more plant-based foods, such as fruits, vegetables and whole grains. Also emphasize lean sources of protein — such as beans, lentils and soy — and lean meats.

Exercise and activity

Increased physical activity or exercise is an essential part of obesity treatment:

Exercise. People with obesity need to get at least 150 minutes a week of moderate-intensity physical activity to prevent further weight gain or to maintain the loss of a modest amount of weight. You probably will need to gradually increase the amount you exercise as your endurance and fitness improve.

Keep moving. Even though regular aerobic exercise is the most efficient way to burn calories and shed excess weight, any extra movement helps burn calories.

Behavior and physiological changes

A behavior modification program can help you make lifestyle changes and lose weight and keep it off. Steps to take include examining your current habits to find out what factors, stresses or situations may have contributed to your obesity.

Weight-loss medication

Weight-loss medications are meant to be used along with diet, exercise and behavior changes, not instead of them. Before selecting a medication for you, your doctor will consider your health history, as well as possible side effects.

The most commonly used medications approved by the U.S. Food and Drug Administration (FDA) for the treatment of obesity include:

- Bupropion-naltrexone (Contrave)
- Liraglutide (Saxenda)
- Orlistat (Alli, Xenical)
- Phentermine-topiramate (Qsymia)

Weight-loss medications may not work for everyone, and the effects may wane over time. When you stop taking a weight-loss medication, you may regain much or all of the weight you lost.

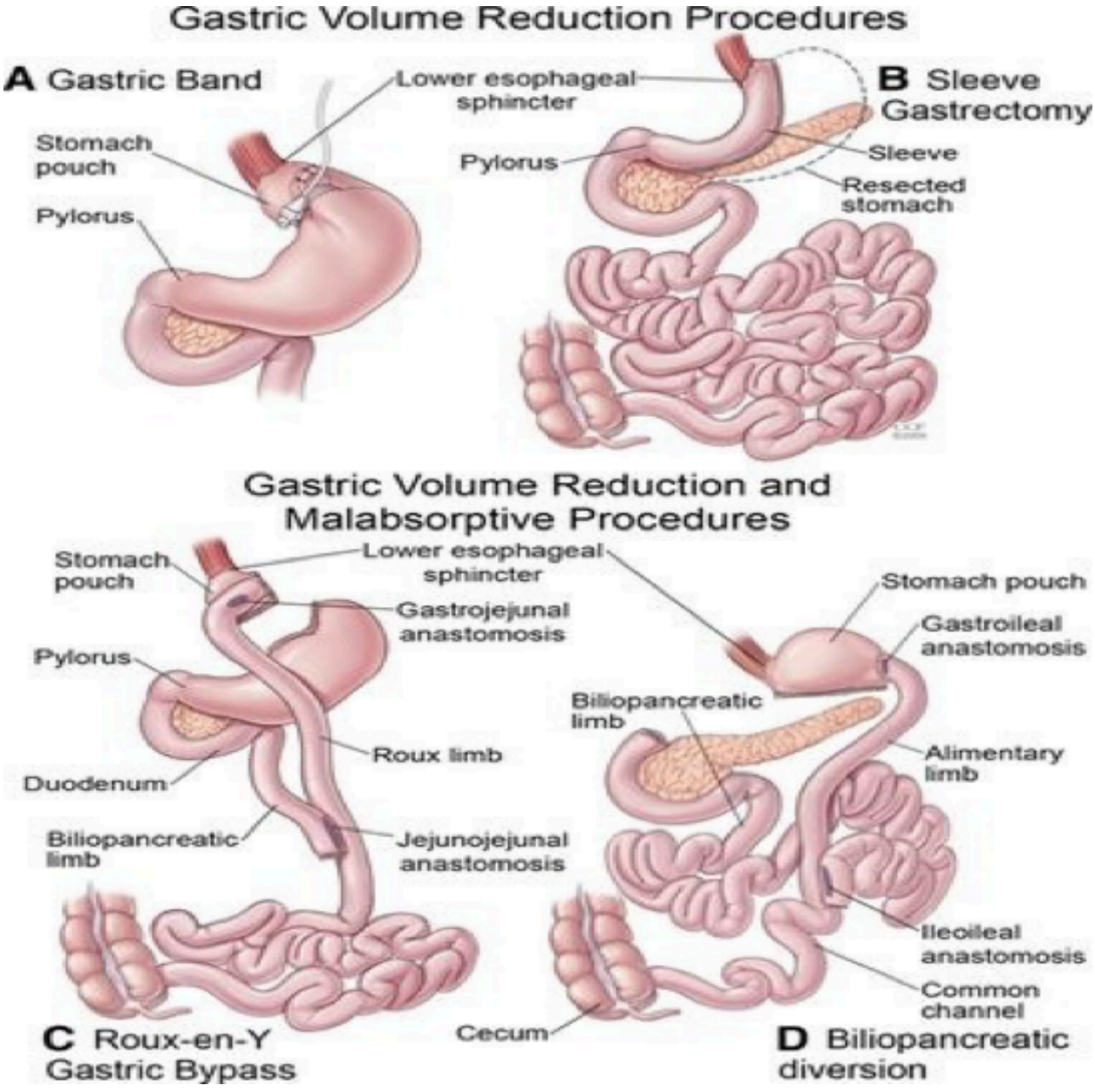

Figure 69: Types of gastric bypass surgeries.

Weight-loss surgery

Also known as bariatric surgery, weight-loss surgery limits the amount of food you're able to comfortably eat or decreases the absorption of food and calories. However, this can also result in nutritional and vitamin deficiencies.

Common weight-loss surgeries include:
Adjustable gastric banding. In this procedure, an inflatable band separates the stomach into two pouches. The surgeon pulls the band tight, like a belt, to create a tiny channel between the two pouches. The band keeps the opening from expanding and is generally designed to stay in place permanently.

Gastric bypass surgery. In gastric bypass (Roux-en-Y), the surgeon creates a small pouch at the top of the stomach. The small intestine is then cut a short distance below the main stomach and connected to the new pouch. Food and liquid flow directly from the pouch into this part of the intestine, bypassing most of the stomach.

Gastric sleeve. In this procedure, part of the stomach is removed, creating a smaller reservoir for food. It's a less complicated surgery than gastric bypass.

Weight-loss success after surgery depends on your commitment to making lifelong changes in your eating and exercise habits.

Other treatments

Other treatments for obesity include:

Hydrogels. Available by prescription, these edible capsules contain tiny particles that absorb water and enlarge in the stomach, to help you feel full. The capsules are taken before meals and are passed through the intestines as stool.

Vagal nerve blockade. This involves implanting a device under the skin of the abdomen that sends intermittent electrical pulses to the abdominal vagus nerve, which tells the brain when the stomach feels empty or full.

Gastric aspirate. In this procedure, a tube is placed through the abdomen into the

stomach. A portion of the stomach contents are drained out after each meal.

Chapter 9

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Diet related NCDS

Definition

are those chronic diseases which are caused by eating unhealthy diet. An unhealthy diet, is the food that is typically high in sugar, saturated fat, and salt and low in vegetables, fruits, and other right nutrient important to the body to function properly.

The main diet related NCDS are: (WHO, 2022)

1. cardiovascular diseases(eg: coronary heart disease, peripheral vascular disease)
2. cancers
3. chronic respiratory diseases (eg: chronic obstructive pulmonary disease, asthma).
4. diabetes type2
5. liver diseases (e.g.: fatty liver disease) (BetterHealth, 2012).

Causes

The main contributing factors to diet-related non-communicable diseases (NCDs) are bad eating practices and lifestyle decisions. Some of the major elements that influence the emergence of NCDs include:

1. High intake of unhealthy foods: consumption of processed:
    - High-salt foods increases blood pressure, which increases the risk of cardiovascular disease and stroke, chronic kidney disease and some cancers.
    - High-sugar foods – excess sugars can contribute to tooth decay and weight gain, leading to overweight and obesity, as well as higher blood pressure, cardiovascular disease and stroke, and some cancers. (WHO, 2020)
    - High-trans fats intake – linked to cardiovascular disease and stroke.
2. Low intake of healthy foods: inadequate or low intake of:
    - fruit and vegetables are linked to several cancers, cardiovascular disease and stroke.
    - fibres, grains, nuts, seeds, micronutrients are linked to diabetes, cardiovascular disease and stroke, and some cancers (Afshin et al., 2019).
3. Alcohol consumption: Excessive alcohol consumption can lead to liver disease, cancer, and other health problems.
4. Tobacco use: Smoking and other forms of tobacco use can increase the risk of various types of cancer, respiratory diseases, and cardiovascular diseases (WHO, 2022).

Epidemiology

- Noncommunicable diseases (NCDs) kill 41 million people each year, equivalent to 74% of all deaths globally.
- Each year, 17 million people die from a NCD before age 70; 86% of these premature deaths occur in low- and middle-income countries.
- Of all NCD deaths, 77% are in low- and middle-income countries.more than three quarters of global NCD deaths (31.4 million) occur.
- Cardiovascular diseases account for most NCD deaths, or 17.9 million people annually, followed by cancers (9.3 million), chronic respiratory diseases (4.1 million), and diabetes (2.0 million including kidney disease deaths caused by diabetes).
- These four groups of diseases account for over 80% of all premature NCD deaths (WHO, 2022)

Unhealthy diets, including those high in ultra-processed foods, are responsible for 8 million NCD deaths a yea. accounting for 19% of non-communicable disease deaths (Vital Strategies, n.d.).

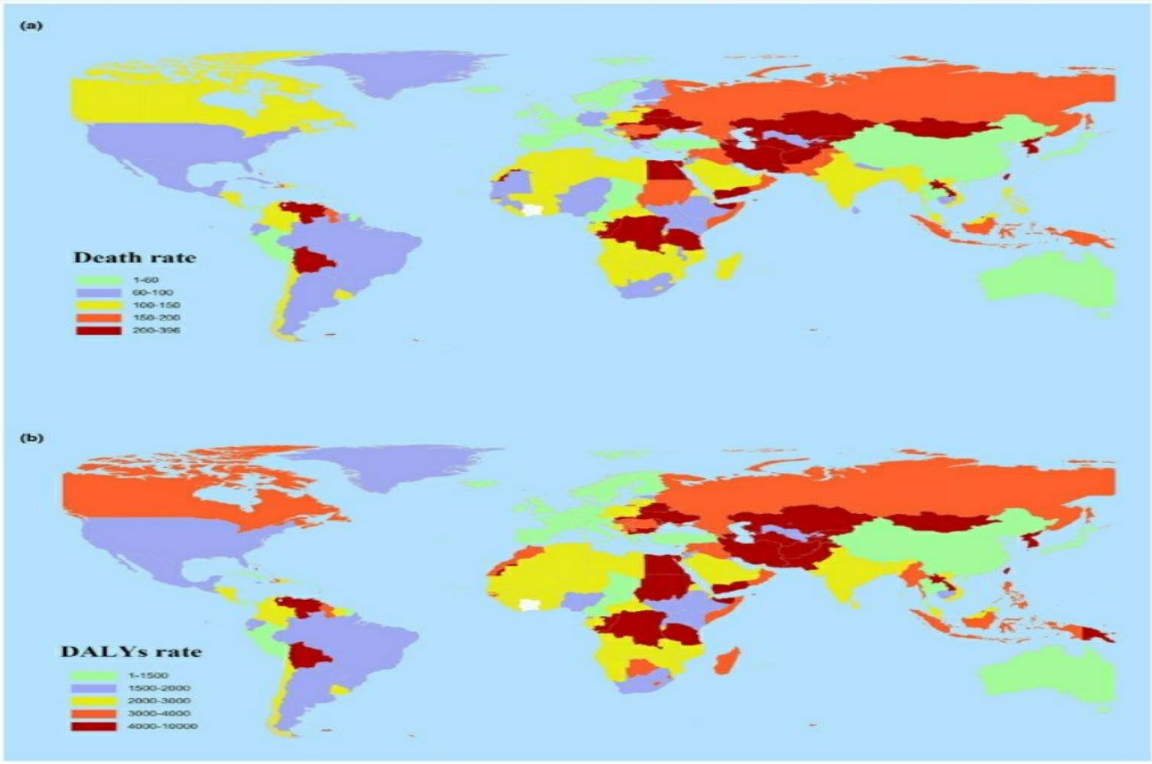

FIGURE 3 Global map of non-communicable disease burden attributable to dietary risks in 2019. (a) death rate (b) DALYs rate. DALYs, disability-adjusted life-years

Figure 70: Patterns for the distribution of non-communicable diseases attributed to dietary risks.

Pathophysiology

It has been demonstrated that the diet alters normal physiology significantly, resulting in dysregulation of the sympathetic nervous system, the renin-angiotensin system, and the

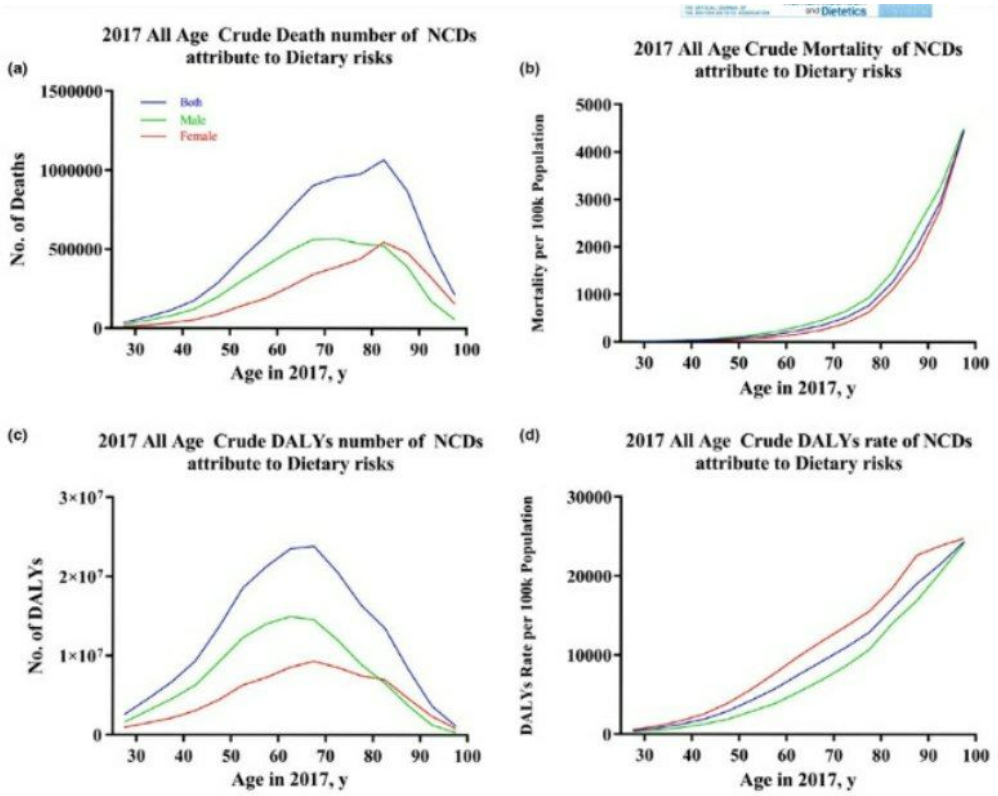
(a)
2017 All Age Crude Death number of NCDs attribute to Dietary risks
No. of Deaths
Both
Male
Female
Age in 2017, y
(b)
2017 All Age Crude Mortality of NCDs attribute to Dietary risks
Mortality per 100k Population
Age in 2017, y
(c)
2017 All Age Crude DALYs number of NCDs attribute to Dietary risks
No. of DALYs
Age in 2017, y
(d)
2017 All Age Crude DALYs rate of NCDs attribute to Dietary risks
DALYs Rate per 100k Population
Age in 2017, y

FIGURE 2 Global burden of non-communicable diseases (NCDs) attributable to dietary risks by age in 2019. (a) death numbers (b) death rate (c) DALYs number (d) DALYs rate. DALYs, disability-adjusted life-years

Figure 71: Patterns for the distribution of non-communicable diseases attributed to dietary risks by age

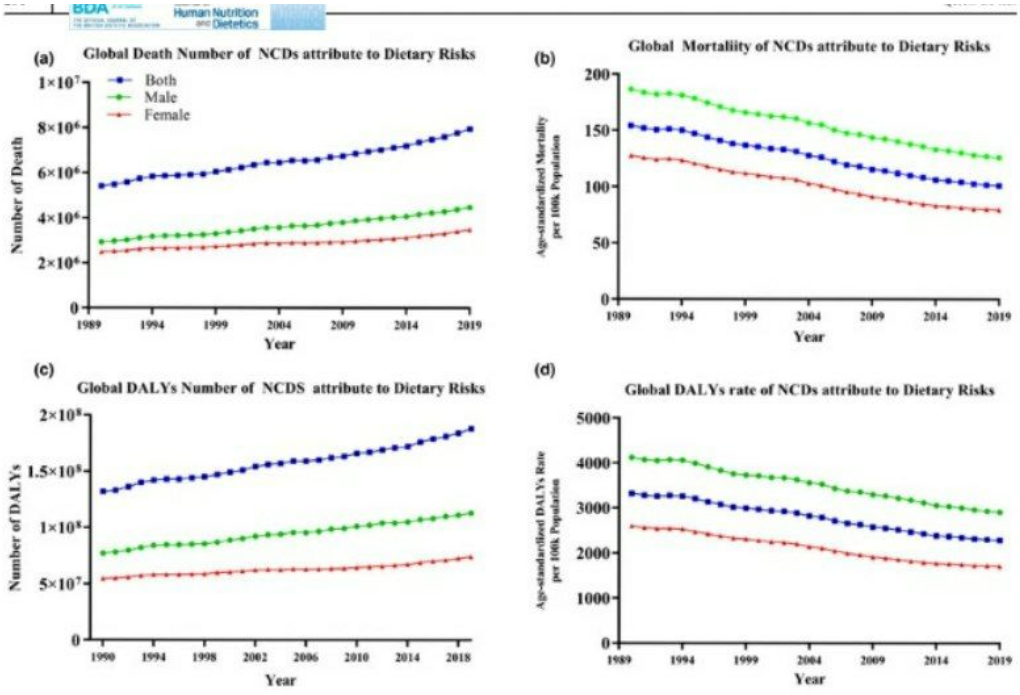

FIGURE 1 Global burden of non-communicable diseases (NCDs) attributable to dietary risks from 1990 to 2019. (a) death number (b) death rate (c) disability-adjusted life-years (DALYs) number (d) DALYs rate

Figure 72: Patterns for the distribution of non-communicable diseases attributed to dietary risks from 1990 to 2019

immune system, as well as disruption of physiological insulin and oxidant/antioxidant homeostasis, all of which are crucial for the emergence of diet-related NCDS (NCD Alliance, 2015).

Clinical picture: symptoms and signs

A. CVD ;
    1. Short of breath
    2. Severe pain or discomfort in the chest
    3. Rapid and irregular heart beat
    4. Dizziness and weakness
    5. Severe headache
    6. Confusion, difficulty speaking or understanding speech
    7. Loss of strength in arms and legs
    8. Dropping face, arm, leg especially on one side of the body
    9. Difficulty of seeing with one or both eyes
    10. Fainting or unconsciousness
B. Symptoms of High Blood pressure;
    1. Severe headaches
    2. Nose bleed
    3. Fatigue or confusion
    4. Vision problems
    5. Chest pain
    6. Difficulty breathing
    7. Irregular heartbeat
    8. Blood in the urine
C. signs / symptoms of cancer ;
    1. Pain (or painless) lumps or boils
    2. Weight loss
    3. Fatigue (feeling weak and tired)
    4. Fever
    5. Changes in skin
    6. Sores that don’t heal
D. common signs / symptoms of CRDs ;
    1. Chronic cough
    2. Shortness of breath
    3. Chronic mucus production
    4. Wheezing
    5. Chronic chest pain
E. common signs and symptoms of diabetes;

- 3 major symptoms:
    1. Frequent urination
    2. Increased thirst and fluid intake
    3. Increased appetite
- General symptoms:
    1. Weight loss
    2. Fatigue
    3. Feeling drowsy after eating
- Other symptoms:
    1. Blurred vision
    2. Itching sensation in the genital area
    3. Wounds which won't heal
    4. Tingling sensation in hands and feet (MOHMS-JCA, 2021; Springmann et al., 2018)

Management and prevention of deit related NCDS:

1. maintain good nutrition containing adequate amounts of body micro/macronutrient and limiting the use of salt, sugar, and saturated fats (Qiao et al., 2021)
2. correct deficiencies that may have occurred
3. give rest to the body or any specific organ
4. meet the requirements of specific conditions
5. detection of diseases at early stages (Budreviciute, A. et al., 2020)
6. each country needs to prepare its management plan, not just with coping models from high-income countries. (Budreviciute, A. et al., 2020)

Chapter: Conclusion

Nutrition is the process of consuming, absorbing, and using nutrients needed by the body for growth, development, and maintenance of life. To receive adequate, appropriate nutrition, people need to consume a healthy diet, which consists of a variety of nutrientsthe substances in foods that nourish the body.

During 2012–2013, WHO member states recognized the seriousness of malnutrition and its effect on global health. Thus, at the United Nation's General Assembly in 2016, the United Nations Decade of Action on Nutrition 2016–2025 was announced. This set a time frame for all forms of malnutrition to be addressed and for diet-related and nutrition targets to be met by 2025.

Malnutrition is a serious global health issue that affects millions of people, particularly children and women in developing countries. It,s an imbalance between the nutrients your body needs to function and the nutrients it gets. It can mean undernutrition or overnutrition. You can be malnourished from an overall lack of calories, or you might have a protein, vitamin or mineral deficiency

Micronutrients- known as vitamins and minerals - are essential components of a high - quality diet and have a profound impact on health. Required only in tiny quantities. Micronutrient deficiencies are often referred to as "hidden hunger" because they develop gradually over time, their devastating impact not seen until irreversible damage has been done Millions of children suffer from stunted growth, cognitive delays, weakened immunity and disease as a result of micronutrient deficiencies.

- Micronutrient deficiencies can undoubtedly have profound influences on the health of at - risk populations. Poor households are the most vulnerable to micronutrient malnutrition , and more permanent solutions are still required. For example, anemia remains a public health problem of huge magnitude, yet little progress in controlling it has been achieved in the developing world.
- Both dietary and non - dietary factors , such as ; access to clean drinking water and sanitation, health care, purchasing power, women's education and empowerment, contribute to micronutrient inadequacy.
- To be successful, fortification and supplementation programs must have high - level government involvement . Fortification programs , for example , require political support , adequate marketing , and long - term commercial commitment .
- Supplementation which is a short term strategy expected to produce quick remediation provided for combating anaemia , and vitamin A deficiency , it has now become a long term strategy for many governments .

- Food - based strategies need to be promoted vigilantly by all stakeholders and the link between agriculture , nutrition , and health and local environment need to be highlighted prominently

Overweight and obesity are defined asabnormal or excessive fat accumulation that presents a risk to health. A body mass index (BMI) over 25 is considered overweight, and over 30 is obese

Obesity is one of the most common diseases in the modern world. As such, it is important to find out what factors both contribute to and reduce the risk of becoming overweight or obese.

- Obesity it is a public health problem and it is a risk factor for several chronic diseases .
- Understanding the role of environmental factors on development of obesity help in control " prevention .
- Healthy eating combined with increased physical activity is the answer

Chapter: Recommendations

At the end, we recommend the following:

Nutritional interventions intended to reduce The Risk of disease in children with malnutrition ,Overweight and Obesity in Adult have three principal objectives:

1. Enhancement of the child's nutritional status, by :-
    A. Nutritional planning
    B. Direct nutrition
2. Reduction of the risk of infection,
3. Reduction in mortality and severity of morbidity following infection.

Interventions to meet these objectives should be targeted at:

1. Nutritional planning: This involves political commitment by the government. A well planned and well executed long term project can accelerate the developmental process and the benefits can be rewarding and permanent. Nutritional planning involves formulation of a nutrition policy and overall long term planning to improve production and supplies of food, ensure its equitable distribution and programs to increase the purchasing power of people. This may include, land reforms, proper guidance in agriculture to help farmers to get better yields from their lands, help in proper marketing of farm produce. To help increasing the capacity of people to buy nutritious food in adequate quantity, income generating activities for the weaker sections of the community, making available good quality food in affordable prices through proper public distribution system.
2. support of the initiation and continuation of exclusive breastfeeding for at least 4 to 6 months postpartum and continuing breastfeeding for at least 2years.
3. improvements in the preparation and use of appropriate weaning Foods.
4. Educate parents about their Child's nutrition values ,by raising their awareness about the importance of nutritious foods.
5. (Maternal education very important which has a significant effect on child's nutritional status)
6. Change population's lifestyle regarding to dietary foods and physical activities
7. Dietary improvements by increasing production of micronutrient rich foods
8. supplementations to all important micronutrients
9. Food fortification through increasing the content of micronutrient in food and improve the nutritional quality of food supply to provide a public health with minimal risk to health .
10. Focus on children's diet by increasing availability, affordability and desirability of nutritious though all stages of life.
11. Adults who are overweight or obese should be encouraged to increase their physical activity levels even if they do not lose weight as a result, because physical activity can bring other health benefits such as reduced risk of type 2 diabetes and cardiovascular disease.

12. Overweight or obese adults should be encouraged to perform at least 30 minutes of at least moderate-intensity physical activity on 5 or more days a week.
13. The activity can be undertaken in one session or several lasting 10 minutes or more. For those who have already achieved this level of activity, an increase in the amount of their physical activity is a reasonable component of any strategy to lose weight. It is generally estimated that 1 pound (0.45kg) of body fat loss requires about 3,500 kcal of energy consumption. As studies on the effect of prescription of muscle strengthening exercise on weight loss are limited, it seems reasonable to recommend overweight/obese people to follow the same muscle strengthening exercise recommendations for the general population for having a balanced exercise program.

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